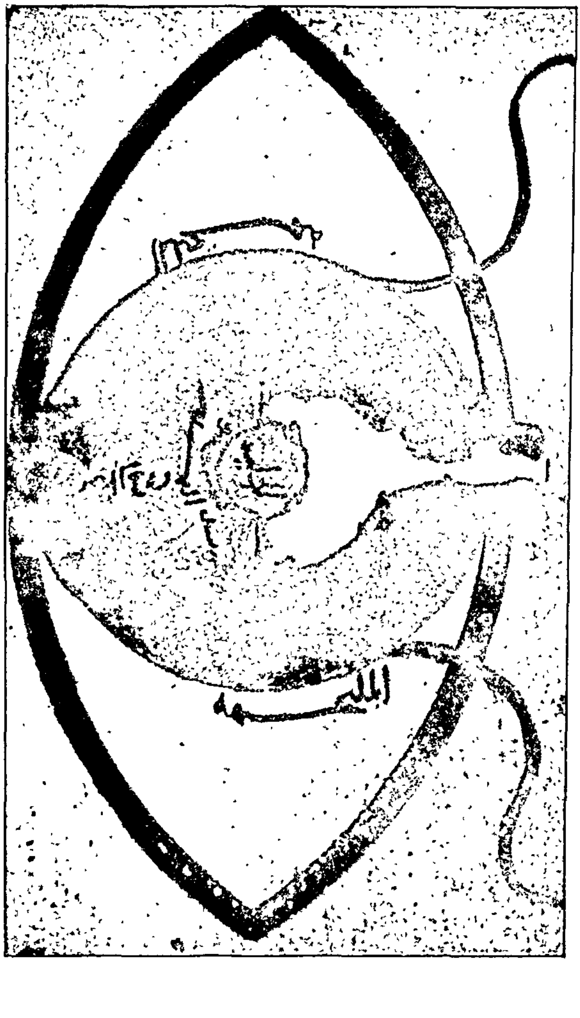

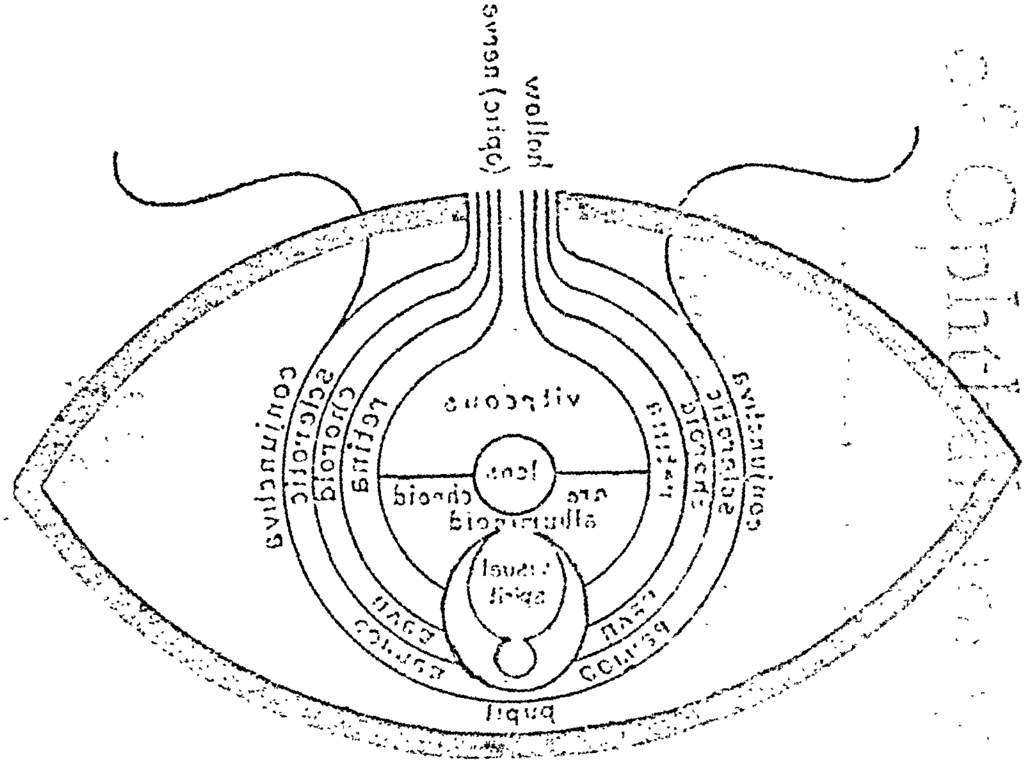

ONE OF THE FIVE EARLIEST KNOWN DIAGRAMS OF THE EYE.

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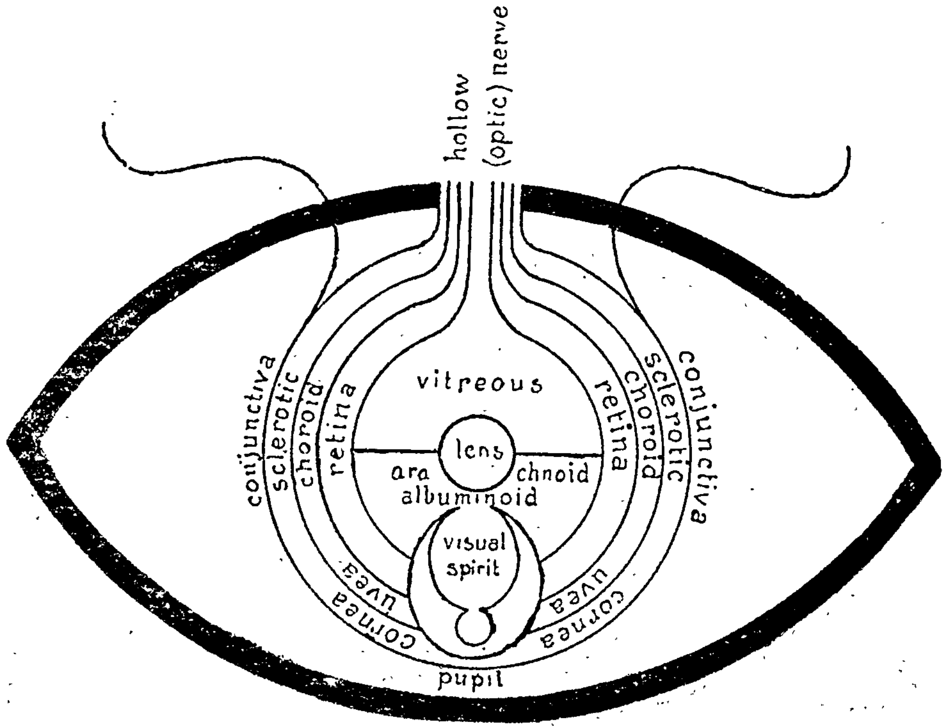

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A Short History of Ophthalmology

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Contents

List of Illustrations

Extract from Preface to First Edition

IN these brief pages no attempt has been made to trace the growth of ophthalmology as an organic whole, phase by phase. It was thought more expedient to trace separately the course of the main streams of development. In the early history of ophthalmology, such basic sciences as anatomy, physiology and optics had hardly any relationship to the practice of the specialty. But, as in other subjects, what was of academic interest on one day was of practical importance the day after. The attempt is here made to record the culmination of apparently unconnected activities into what constitutes modern ophthalmology. Such a method of approach has the disadvantage of the implication it carries that ophthalmology is a finished process, the components of which are being viewed, when of course it is an actively developing subject with no finality; but it is hoped that the introductory chapter may help to give the more proper perspective.

To Mr. R. R. James and Dr. Laurence Phillips I am greatly obliged for many suggestions and for their kindness in reading the proofs. To Dr. Max Sorsby I am indebted for preparing the Index. Less personal, but nevertheless very real obligations are owing to the writings of the various historians of ophthalmology, especially Hirschberg, Magnus, James and Meyerhof.

Preface to Second Edition

THE general plan of the book has been left undisturbed. Some inaccuracies have been corrected, significant omissions made good and some judgments modified.

A. S.

I. INTRODUCTORY

I. THE ANCIENT EAST

ACCORDING to Herodotus the Babylonians had no physicians; the patient was brought out into the market-place and all passers-by had to confer with him 'to discover whether they have themselves been afflicted with the same disease or have seen others so afflicted . . . and advise him to have recourse to the same treatment as that by which they escaped a similar disease, or as they have known to cure others.'

But the Code of Hammurabi, with its rewards and penalties for physicians, gives a glimpse of an already more highly organized system at a period earlier than 2000 B.C. – long before Herodotus. The Code enacts that for a successful operation which saves the eye of the patient the fee be ten shekels of silver in the case of a 'gentleman,' but only five shekels and two shekels in the case of a poor man and owned slave respectively. For an unsuccessful operation on a freeman causing death or the loss of the eye, the surgeon shall have his hands cut off; in the case of a slave the penalty was to replace him by another.

Babylonian medicine was probably in the hands of the priests of the healing divinity Ea and his son Marduk, whilst surgery, as almost everywhere else in early medicine, was in the hands of a special class of skilled hand-workers. The etymological derivation of surgery is significant, for χειρουργία means handicraft. The priestly, non-operative practice was not regulated by law; but that the work of the surgeons was not altogether despised is shown by the very liberal scale of fees, for five shekels was equivalent to the yearly rent of a good type of house and represented 150 times the daily wage of a workman (1/30 shekel). The medical practice of the priests

was a mixture of superstition and ignorance; treatment consisted of incantations and also the administration of foul remedies – probably to disgust the demons causing the disease. It would appear that the practice of the surgeons was supervised by the priests, but it is by no means clear what their work was. It is possible that the greater part of Babylonian surgery consisted of couching for cataract. On the other hand, the eye operation spoken of may merely have been incision of an abscess of the lacrimal sac. The whole evidence turns on the significance of an obscure word in the Code, *naqabtu*.

The earliest records of Egyptian medicine date back to a period not much later than the Code of Hammurabi, the Edwin Smith papyrus to *c.* 1600 B.C., the Brugsch papyrus to *c.* 1300 B.C., and the Ebers papyrus to *c.* 1550 B.C. A remarkably advanced state of ophthalmology can be inferred from the Ebers papyrus in which a section is devoted to eye diseases, treatment rather than clinical descriptions being given. Incantations, foul applications and all the other manifestations of superstitious ignorance abound, but there is evidence of an advance that must have involved centuries of empirical practice and observation. The most significant development is the recognition of a number of distinct clinical entities. According to Ebers the Egyptians knew such conditions as blepharitis, chalazion, ectropion, entropion, trichiasis, granulations, chemosis, pinguecula, pterygium, leucoma, staphyloma, iritis, cataract, hydrophthalmos, 'blood in the eye', inflammation, ophthalmoplegia and dacryocystitis. The attempt at differential [illegible] implies a degree of differential diagnosis; nevertheless it was still the medicine of the temple that they practised. Indeed the Ebers papyrus is probably the work of priests, though it is not, as was once thought, a part of the lost six medical books of Hermes containing the divine knowledge of healing as set down by the Egyptian priests.

There is no evidence that Egyptian surgery had made any marked advance; the only surgical procedure mentioned in the Ebers papyrus is epilation, a practice that must have been common judging from the frequency with which epilation forceps have been found in relics of the New Empire.

Later development in Egypt brought but little advance, though there is much evidence that Egyptian ophthalmology was held in high esteem in the Ancient world. Herodotus relates that Cyrus of Persia sent to Amazis, the king of Egypt, for a physician to cure him of his eye trouble. The decline of Egyptian civilization brought with it that type of specialization which is based not on expert knowledge of a detailed field, but on ignorance of every other subject. Both the prophet Jeremiah and Herodotus found the country full of physicians and Herodotus remarks that 'one treats only the diseases of the eye, another those of the head, the teeth, the abdomen, or of the internal organs'.

Nowhere in the Ancient East was medicine ever freed from the shackles of supernatural belief. Observation was coloured by preconceived notions of the demoniacal origin of disease. Here and there a glimpse of a modern procedure is seen, based on methods and premises different from ours. In Hindu medicine there is a suggestion, in the writings of Suçruta, of the earliest record of surgical treatment of cataract by couching. In Hebrew writings there is a textually obscure reference to improvement of a woman's appearance by having a golden eye [in the place of a missing one], an interesting and significant remark in the light of later history, for prostheses made of gold were the first to be used and were not introduced until the sixteenth century at the time of Ambroise Paré. Early Greek medicine differed in no essentials from that of the rest of the Ancient world. There was the same priestcraft, the same temple worship and supernatural cures. Nor were these temples as holy as they seemed. It was only with the rise of the

Asclepiadae, a group claiming descent from the God Aesculapius, but dissociating themselves from the priests of the temples, that Greek medicine began. Outstanding amongst these Asclepiads was Hippocrates the Second, also known as Hippocrates the Great, or simply as Hippocrates, born on the island of Cos. The Asclepiadae finally liberated medicine from the thrall of the supernatural. Their method is the method of modern medicine: the study of disease as an objective natural phenomenon. The lasting achievements of the Greeks are commemorated in the term physician, derived from φύσις, *nature*. Henceforth the physician was essentially no longer a priest but a naturalist.

II. THE GREEK PERIOD

Ophthalmology benefited at the hands of Hippocrates and his immediate followers mainly in a negative way – in discarding the supernatural element rather than in any definite advance in the understanding of ocular disease. Their notions of the structure and function of the eye had hardly advanced, if at all, beyond that which the much older Egyptian civilization knew, though a predecessor of Hippocrates, Alcmaeon, is credited with the discovery of the optic nerve. Their recognition of eye disease was confined to what could be observed and deduced from a knowledge limited to the superficial anatomy of the eye combined with an utter lack of understanding of ocular physiology. It is mainly in its influence on the further development of ophthalmology rather than in its achievement, that Hippocratic ophthalmology is remarkable, though it is well to recall that its treatment of some forms of conjunctivitis by irritation persisted till lately in the treatment of trachoma. When it went astray it was wrong in the same way as the modern world is wrong when mistaken treatment

is given on the strength of a wrong pathology; its failures were different in nature from the failures of those who invoked the aid of the gods or attempted to cast out the devil.

Greek medicine stretches over a period much longer than the medicine of the modern period. From the appearance of Hippocrates to the end of the fruitful period of Rome is well over 800 years. During that time there was a continual development in which ophthalmology shared. Greek medicine soon became extinguished on its native soil but developed apace, first in Alexandria and then in Rome. Of the great achievements of the Alexandrian period one can only infer, by comparing the end of the purely Greek period with the beginning of the Roman period, the actual records of the Alexandrian school having been lost. The study of human anatomy began in Alexandria, and the earliest Roman writings on the anatomy of the eye, those of Rufus, are a measure of the advance made by the Alexandrian school. After the decline of Alexandria, it was in Rome that the Greek spirit found a home. There medicine was so entirely Greek that the Romans who practised it felt compelled to adopt Greek names for themselves and their remedies. Of the writings of this period there remain those of Celsus, Pliny and Galen; references to other writers whose works are lost are to be found in these and later books. Galen's strictly ophthalmic writings have been lost.

Of a period later than Galen's there are the works of Aetius of Amida and of Paul of Aegina, giving a full account of the medical and surgical practice towards the end of the Byzantine period. In Celsus there are detailed descriptions of couching for cataract, of operations for ankyloblepharon, dacryocystitis, and of plastic procedures for trichiasis, lagophthalmos and ectropion. Hypopyon is first mentioned by Galen. Of Galen's contributions to ophthalmology it is perhaps enough to say that nothing of any value was added to his anatomy of the eye till the beginning of the seventeenth

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century; his theory of vision was however a grievous error. The later writers of the Greek period added some details to the practice of ophthalmology, but nothing whatever to its theory. The beacon lit by the Asclepiadae, and tended by Alexandria and Rome, was slowly sinking in a world that was plunging deeper and deeper into the mists of the Dark Ages.

III. THE ARABIAN PERIOD

The fitfully flickering flame of civilization was saved from extinction by the invading hordes of rude Oriental conquerors sweeping across the known world under the banner of Allah. As before in the case of Rome, so once again Greece took its captors captive. By means of translations, first into Syriac and later into Arabic, a knowledge of the older Greek civilization was spread throughout the Mohammedan world. Ophthalmology took a new lease of life, though progress was severely handicapped by the lack of anatomical studies. Hospitals, departmentalized very much in the modern manner, grew up and ophthalmic departments were always large and important. Many operative procedures known to Galen and his successors were perfected and some important additions were made. Numerous treatises on diseases of the eye appeared, all drawing their inspiration from the Greek writings. But the centuries of Arabian dominance lacked the eager questing that characterized Greece. The Arabians perfected old procedures rather than explored new avenues; they revered rather than challenged the authority of tradition. So heavily did the hand of dead ages lie upon them, that though there is much that is valuable in Arabian ophthalmology, it is incidental rather than the result of a conscious effort. Not infrequently they stumbled on facts and conceptions that could not be harmonized with the traditional knowledge, but they only

cut their new cloth into ill-fitting archaic patterns. They had not learnt the crowning wisdom that fact is greater than dogma. It is characteristic of the period that Ali ben Isa (Jesus Hali), Alcoatin and Ammar ben Ali wrote textbooks that were used for centuries.

Like the Western civilization that followed it, the Arabian period was not a national movement. It was Arabian in language only; the men who made it were of that variety of nationality and religion that were to be found between Cordova and Baghdad. When decay ultimately overtook the Arabian renaissance, the knowledge that it had preserved had already been handed on to the rising civilization of Western Europe by means of translations into Latin from the Arabic versions of the Greek masters. Many mistakes were perpetuated by these translations and retranslations and it needed the European renaissance to direct onward the pure stream of Greek thought.

IV. THE WESTERN MIDDLE AGES

Whilst the Arabians nursed and revived a moribund civilization, knowledge did not altogether perish in the western domains of what was once the Roman Empire. Here and there in the monasteries intellectual life flickered, and some stray sparks would be brought by Jews coming from Mohammedan lands. The beginnings of a systematized intellectual effort is found in the schools of Salerno and Montpellier. In the eleventh century Constantinus Africanus, a widely travelled man and at one time teacher in Salerno, translated Arabic writings into Latin, thus beginning a movement that gathered speed with the years. But ophthalmology in those days of twilight was nevertheless little more than a debased handicraft; couching for cataract, like cutting for stone, was an operation which

everyone was allowed to perform, and was in fact left to itinerant practitioners. The regular practitioners of surgery advised against eye operations and paid but scanty attention to eye disease in general. The writings of Peter the Spaniard (later Pope John XXI) are a treatise on the hygiene of the eye and contain no reference to surgical treatment. The writings of Master Zacharias, a Salernitan of the twelfth century, are of little significance, but those of Benevenutus Grassus are of considerable importance in the history of ophthalmology. Little is known of the author, but the book had a great influence in spreading knowledge of eye disease. The original seems to have been written in Hebrew and there are translations in Latin, Provençal, Old French and Old English. There is little new in the book; it is essentially a good summary of Greek and Arabian teaching. The importance that mediaeval ophthalmology attached to it can be gathered from the fact that it is the only ophthalmic incunable. Guy de Chauliac and John Yperman were influenced by Benevenutus' book, Yperman himself contributing to ophthalmology the conception of contagion in ophthalmia.

If the Western Middle Ages produced no memorable oculists, it produced geniuses who in their versatility contributed to ophthalmology. Roger Bacon's ophthalmic achievements include the rediscovery of the crossing of the optic nerves at the chiasma and the first mention of convex lenses for presbyopia, whilst Leonardo da Vinci either realized, or came very near to realizing, the principle of the *camera obscura* as applied to the eye.

V. THE MODERN PERIOD

Since the practice of ophthalmology had hardly advanced during the long centuries that followed Greek medicine at its

height in the Rome of Galen, it had little to gain at the Renaissance by merely looking backward. Further advance in ophthalmology was made possible by the study of the anatomy of the eye, and by an understanding of the mechanism of vision. This was the work of the sixteenth and seventeenth centuries and paved the way for the great pathological and clinical progress of the eighteenth century, the century of cataract extraction and the artificial pupil. The first half of the nineteenth century was a remarkable period of consolidation, and the second half brought the operative treatment of glaucoma, whilst the ophthalmoscope opened a world undreamt of and raised ophthalmology to the most exact of clinical studies.

II. ANATOMY

FIGURES illustrating the anatomy of the eye first made their appearance in Arabian literature. Arabic manuscripts are extant in which reference is made in the text to figures, themselves missing, though space for them is provided. The earliest drawing as yet available appears in Hunain ibn Is-hâq's *Book of the Ten Treatises on the Eye*, recently discovered and edited by Meyerhof (frontispiece).

Through lack of illustrations it is difficult to get a clear conception of Greek and Roman knowledge of ocular anatomy, for the descriptions are frequently not only scanty, but confused through a multitude of names, which may or may not have had the same meaning.

Pre-Hippocratic anatomy had hardly passed beyond the stage of recognizing a transparent cornea continuous with an opaque sclerotic, the whole being lined by a layer with a perforation which formed the pupil. These two layers enclosed a fluid substance. This conception of the anatomy of the eye was not based on detailed observation, but on speculation as to the nature of vision. The fluid in the eye was regarded as the principle of vision and a tube leading from the eye to the brain, allowing for the free movement of this visual substance, led Alcmaeon to postulate the *πόρος, poros*. This postulated hollow tube is hardly the solid optic nerve of modern anatomy. An advance on these speculations is to be found with Aristotle, who obviously dissected animal eyes (fig. 1). Three layers instead of two are recognized, though knowledge of the retina hardly went beyond the recognition of its existence. Knowledge of the structure of the cavity of the eye was vague. There was no recognition of the anterior chamber; it was held that the three layers of the eye are intimately apposed to each other. The ocular fluid was considered as of uniform consis-

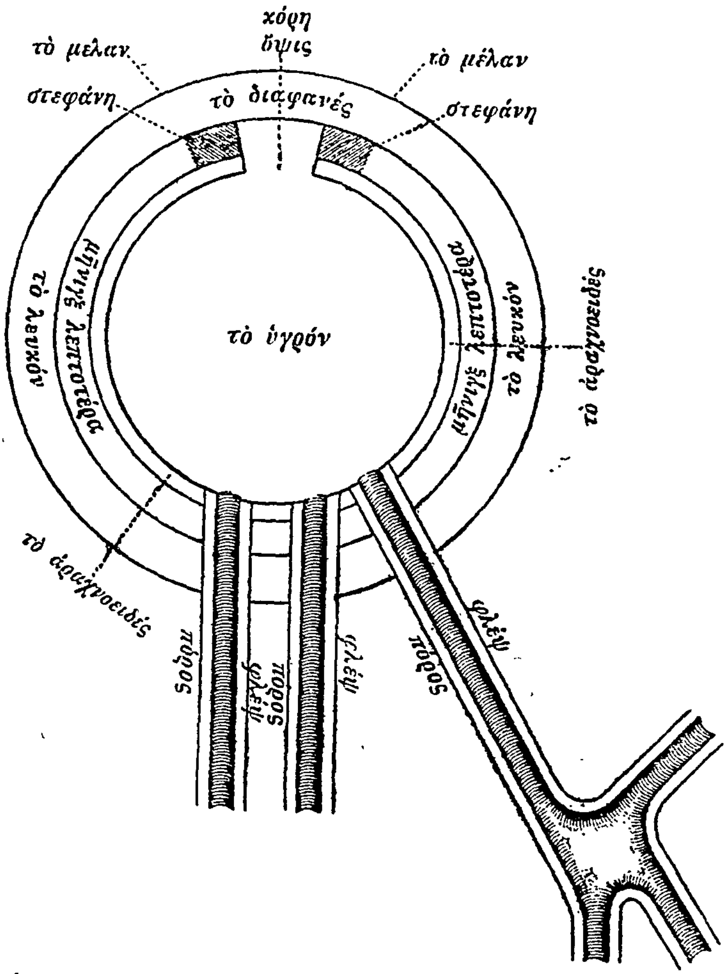

FIG. 1.—The structure of the eye as conceived by Hippocrates and Aristotle. Reconstruction by Magnus.

tency, though some differentiation occurred on exposure to air; the lens, as far as it was recognized, was thus regarded as a post-mortem manifestation. The hollow tube of Alcmaeon became three in number, one of which entered the skull and joined with a corresponding structure from the other eye. The recognition of the chiasma and of ocular vessels had therefore been achieved.

The Alexandrian school contributed largely to the knowledge of the anatomy of the eye. Herophilus in particular seems to have devoted much attention to the eye; from a reference in Aetius it is clear that he wrote a special treatise on it. As no manuscripts of this period have survived one has to rely on Celsus for information (fig. 2), and Celsus' account is by no means clear for the reason, as Hirschberg puts it, that he did not understand the subject. There is a clear recognition of the existence of the lens, a drop-like body named κρυσταλλοίδες, *crystalloides*. Whilst no anterior chamber is indicated – the second layer is still contiguous with the first, except in the pupillary area, which is a mere perforation – it is recognized that the retina does not come up to the cornea; it forms a smaller enclosing structure, and comes to surround the ocular fluid including the lens. This arrangement leaves a large empty space – *locus vacuus* – between the two outer layers and the smaller retina. As this *locus vacuus* is also spoken of as containing '*humor*', a near approach to the appreciation of the existence of the anterior chamber may have been made. What exactly Celsus knew of the optic nerve is not clear: he does not speak of any hollow canal, nor of a continuation of the retina into the nerve. The optic nerve probably appeared to him as a continuation of the fused two outer layers of the eye.

With Rufus a much clearer conception of ocular structure emerges. The conjunctiva is recognized, though of course not distinct from the capsule of Tenon, which indeed was not described till 1806. Under the name of ἐπιδερμίς, *epidermis*,

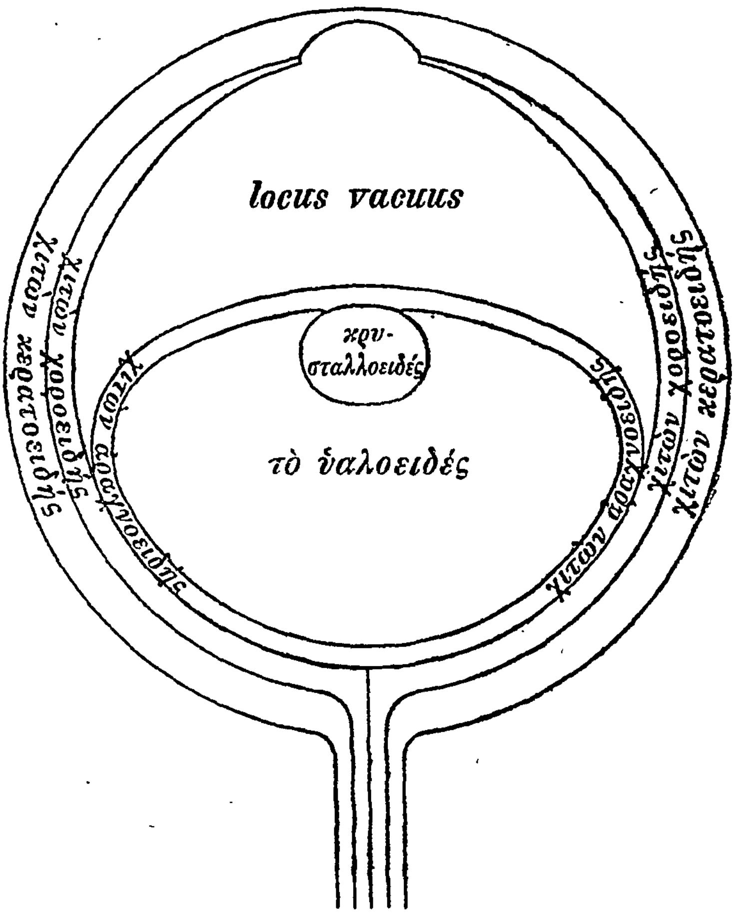

FIG. 2.—The eye as described by Celsus. Reconstruction by Magnus.

it is regarded as a fourth covering layer extending from the junction of the cornea and sclerotic to the posterior pole. The corneo-scleral junction, στεφάνη, *stephane*, is regarded as also indicating the site where the retina branches off to line the posterior aspect (no longer the anterior) of the lens. The lens itself is invested with a lining layer, but whether this is a distinct layer or a decomposition product of the lens [? liquefied cortex] is not clear to Rufus. Of significance is Rufus' conception of the internal structure: as Magnus points out, this approaches the modern view. Two spaces are recognized, one lying between the cornea and iris, and another behind the lens. The first space, a mere chink, was filled with a fluid very much like water, whilst the second contains a substance like the white of a raw egg.

Four serious defects mar the description by Rufus. He failed to recognize the existence of the posterior chamber, the greater curvature of the cornea as compared with the sclerotic, and the inequality in the curvature of the lens surfaces; and his reference to the optic nerve is most scanty. These defects were in a large measure rectified by Galen (fig. 3).

Just how much the description given by Galen is the result of his own observations or that of predecessors is not known. But Galen's account is of significance not only because it marked an advance, but even more because no advance was made on it till after Vesalius. If pre-Hippocratic anatomy was speculative, and Alexandrian anatomy truly descriptive, anatomy after Galen became an historical exercise on which commentators were busy for well over a thousand years.

A fairly clear recognition of the ciliary body seems to have been arrived at. The corneo-scleral junction – one name for which was *iris*, a designation that persisted till well into the eighteenth century – was also the seat of fusion of the choroid and retina, where in addition a layer lining the anterior surface of the lens also terminated. The posterior chamber was now

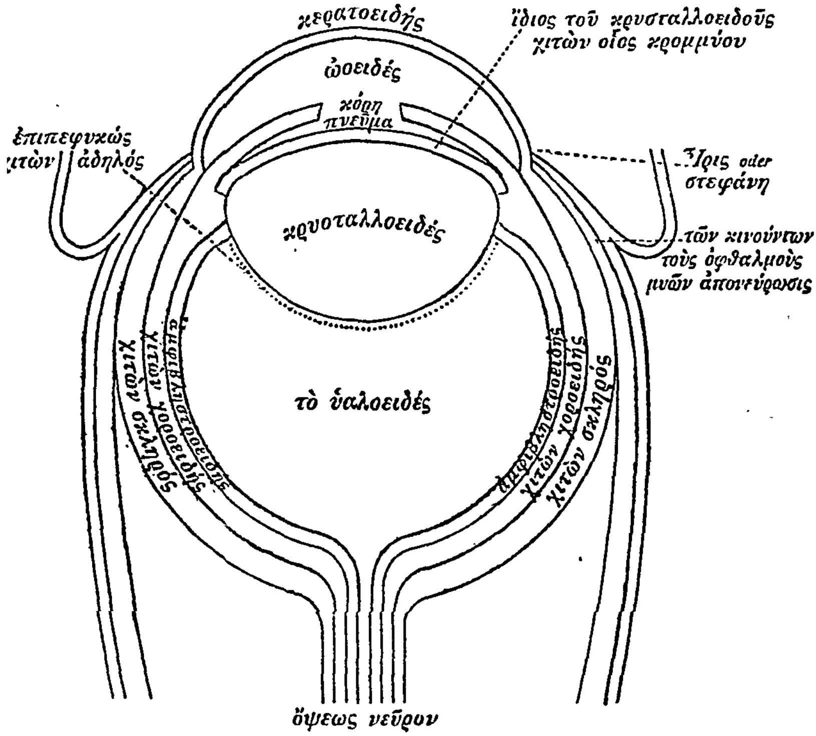

FIG. 3.—The eye as described by Galen. Reconstruction by Magnus.

known, as was also the fact that it contains the same fluid as the anterior chamber. The greater curvature of the posterior surface of the lens was likewise recognized; the lens itself was held to fuse with the choroid by which it was kept in position.

The recognition of the greater curvature of the cornea over the sclerotic was obviously the result of observation, but that of the existence of the posterior chamber was the result of speculation. Galen's writings are not clear on the subject, and as Magnus points out, he could not possibly find a space between the lens and iris in an eye cut open without the modern methods of preliminary fixation; but his theory of vision which postulated dilatation of the pupil by πνεῦμα, *pneuma*, called for a posterior chamber through which the pneuma could diffuse on to the lens.

Speculation also entered into the description of the optic nerve. Whilst Galen recognized its solid structure he had to maintain a central hollow canal, in the sense of Alcmaeon. At the chiasma fusion of the hollow canals of both nerves took place. That Galen drew on animal dissection is clearly seen from his description of extra-ocular muscles, of which there are seven – the six of present-day human anatomy with an additional massive ensheathing muscle which arises at the point where the optic nerve enters the orbit – obviously the *retractor bulbi* of comparative anatomy. Furthermore, in describing the lacrimal apparatus he speaks of two glands, one in the upper and one in the lower lid. Galen recognized another source of tears – glands in the conjunctiva of the lids. The conjunctiva itself he held to be derived from the pericranium.

Arabian anatomy was the anatomy of Galen modified not by the evidence of dissection but by conclusions drawn from speculation. Depression of cataract was extensively practised; and as the prevailing view was that a corrupted humour in front of the lens was displaced in the process, it was necessary

to conceive the lens as being situated farther back than in Galen's scheme. This view as to the seat of the lens persisted till the beginning of the seventeenth century.

With the coming of Vesalius, anatomy turned once more from speculation and commentaries to dispassionate observation. But to ocular anatomy Vesalius contributed nothing (fig. 4). His teaching is distinctly inferior to that of Galen and even of Arabian ophthalmology. The recognition of the greater curvature of the cornea over the sclerotic, and of the posterior surface of the lens over the anterior, is lost. A central position of the lens is once more in evidence. Even more astounding is Vesalius' acceptance of Galen's *retractor bulbi*.

Modern anatomy of the eye did not emerge till the physicists had demolished the old conceptions of the nature of vision. It began when it was realized that the lens is not the seat of vision, but part of a refractive system. With Fabricius as a precursor in showing the true position of the lens (A.D. 1600), a host of observers rapidly built up the basis of the anatomical scheme as we know it today. Fallopius rediscovered the greater curvature of the cornea and stressed the difference in structure as between the cornea and sclerotic. A clearer view of the capsule of the lens and a description of the hyaloid membrane likewise came from him. He differed from Vesalius in regarding the ciliary body as a membrane, and held it to be a ligament binding the lens to the choroid and he disproved the existence of the *retractor bulbi* in man. Ruysch, who studied the vascular structure of the choroid, is also responsible for showing the existence of circular muscle fibres in the iris. Briggs, who is remembered for his demonstration of the existence of the optic papilla (regarded by him as a projection, as its name implies), showed that the retina extended up to the ciliary 'ligament'. What the sixteenth century began falteringly was well done in the seventeenth. A comparison of two

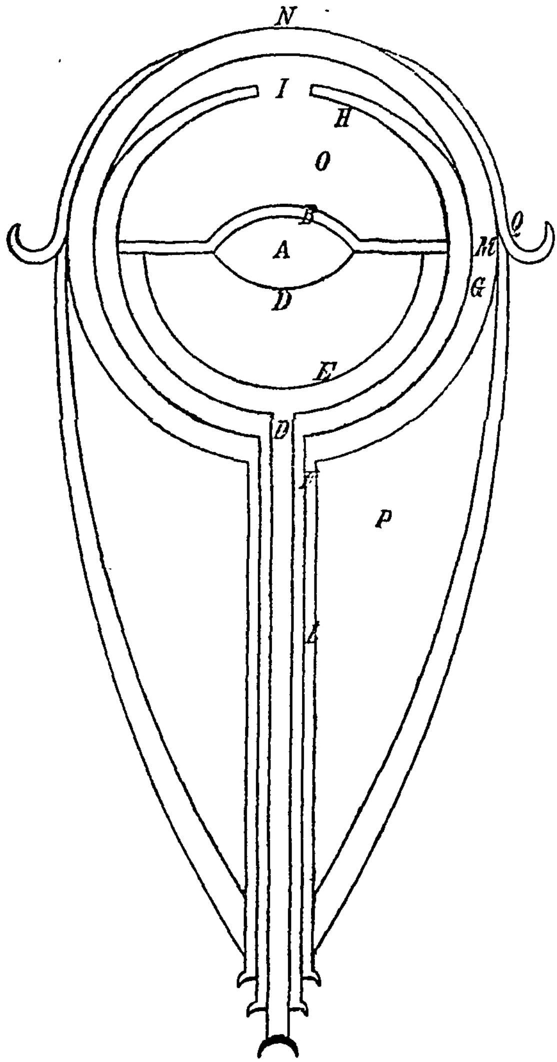

FIG. 4.—Illustration from Vesalius (1514–1565).

reproductions showing the state of anatomical knowledge towards the beginning and the end of the seventeenth century is of interest (figs. 5 and 6).

The finer methods of anatomical study were first used in that century; Ruysch employed injected preparations for the study of the vascular system of the eye; Malpighi used the hand-lens and Leeuwenhoek made the first observations with the microscope; but it was left for the succeeding century to introduce the study of the frozen eye, an innovation due to Petit. The combination of these methods led to the rise of a detailed anatomy, for the bold outlines were by now firmly established. Petit was the first to attempt measurements of the components of the eye. Priority in the description of Descemet's membrane was the subject of a wordy dispute between Demours and Descemet, but its first indication is really to be found in Duddell.

In studying the constitution of the lens, Morgagni found fluid between the capsule and the lens fibres. This fluid was held to nourish the lens – a mistaken notion but one which, at any rate, was an advance on the belief that the lens and cornea contained *vasa serosa*, which possessed the property of impermeability to blood-corpuscles. To the anatomy of this period belongs the description of the spaces of Fontana, as also the discovery by Demours of the canal of Petit, so named by him; the Zonula of Zinn commemorates the name of an observer who also contributed studies on the blood-vessels around the entry of the optic nerve (*circulus arteriosus* of Zinn) and on the action of the ciliary body.

The presence of muscle fibres in the ciliary body was a matter of much discussion; some held with Morgagni that they existed and affected accommodation, others with Zinn, that they were non-existent. Similarly contraction and dilatation of the pupil were explained on the conflicting views of a system of circular and radial fibres and on the view that

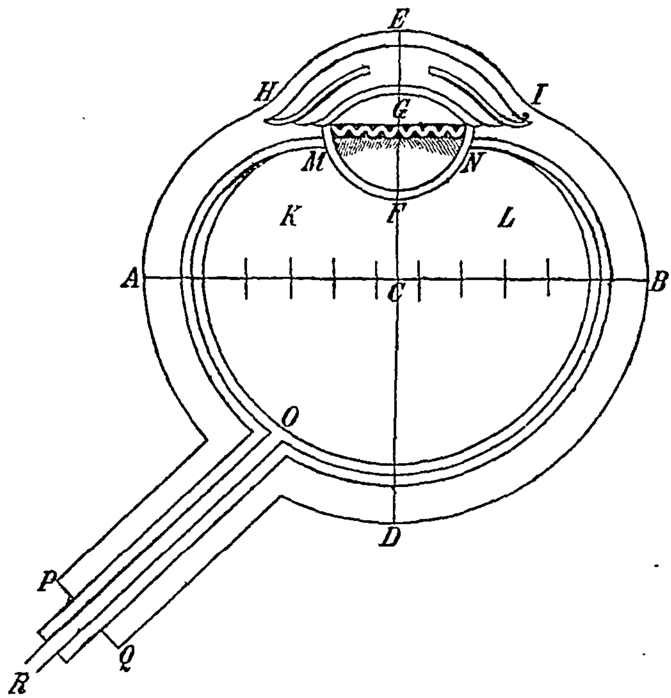

FIG. 5—Illustration from Scheiner (1575–1650).

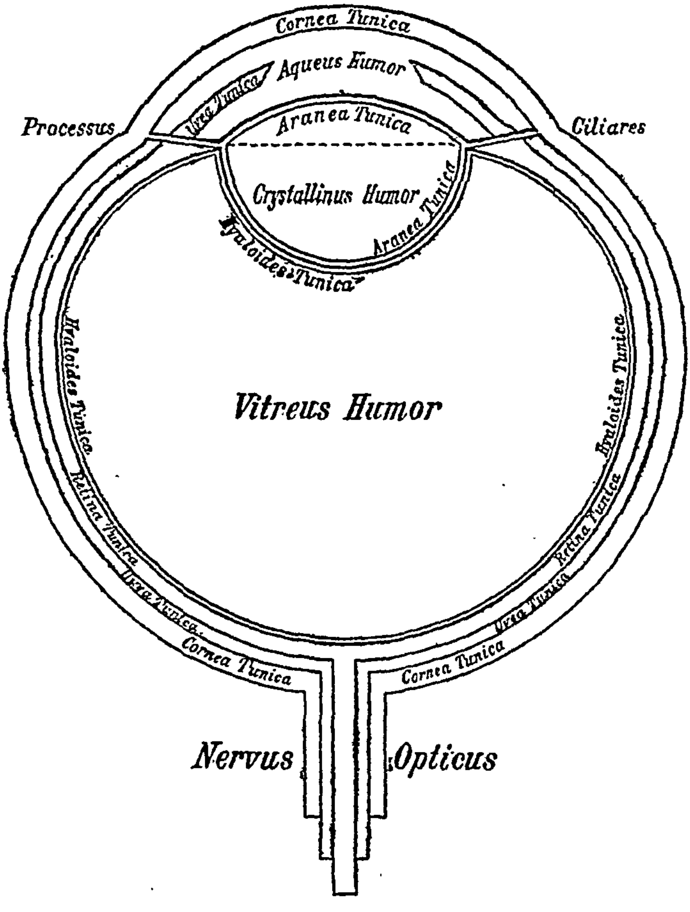

FIG. 6.—Illustration from Molinetti (?–1673).

different degrees of congestion of the vessels of the iris produced changes in the size of the pupil.

It is noteworthy that even at this late stage some gross points were still unsettled. Though Petit in 1728 had clearly demonstrated the posterior chamber, its existence was being questioned down to 1855 and it was not until the work of Helmholtz, Henle and Arlt that this was finally settled.

Whilst by the end of the eighteenth century the uveal tract had been fairly well described, the retina was barely recognized, for the day of cellular anatomy had not yet come. At the turn of the century Buzzi, Sömmering and Reil described the macula lutea. The additions to our knowledge of the anatomy of the eye during the nineteenth century are largely the history of the consequences of the introduction of the compound microscope and the rise of the cellular theory.

The advances recorded during the earlier part of the nineteenth century, *before the introduction of the microscope*, are typified by the description of Jacob's membrane. Jacob described a serous layer in the eye, lying between the retina and the choroid; this ultimately came to be regarded as a constituent part of the retina, which was held to consist of three layers, a limiting layer, a nervous layer – the retina proper – and Jacob's membrane. Jacob's membrane is indeed nothing else than the rods and cones of modern histology. To this period belongs also the discovery of the canal of Schlemm.

The compound microscope opened a new realm of observation, and the realization of the significance of the new facts which were rapidly gathered, culminated in Schwann's theory that all living matter consists of cells. As early as 1722 Leeuwenhoek had noted the rods and cones of the retina, but their existence had to be rediscovered in 1834 by Treviranus. And just as the retina was gradually being recognized, so other tissues were studied by the new micro-

scopic methods. In a few brilliant years of intense work Bowman almost constructed a new anatomy of the eye; his work on the cornea and ciliary muscle is particularly noteworthy. Abroad Pappenheim, Henle and many others added greatly to the new knowledge. The introduction of staining methods brings the history of the anatomy of the eye to the period through which we are still passing, whilst the still more recent method of tissue culture, introduced by Carrel, and as yet almost unapplied to the eye, is opening a new chapter which aims at studying the behaviour rather than the structure of cells.

III. PHYSIOLOGY

THE nature of vision has been the subject of much speculation since the earliest days of systematized knowledge. To the natural philosophers of pre-Hippocratic days, vision was the result of information gathered by antennae-like rays emitted by the eye; these rays on striking an object were deflected back to the eye, conveying information of the outer world.

Such information would in turn be transmitted along the hollow tube connecting the eye with the brain. This view, modified in one form or other, persisted in clinical ophthalmology, though not without challenge, till the beginning of the seventeenth century. Whilst the modifications constitute the history of the development of ocular physiology, the challenges were merely brilliant asides.

The modifications that this theory underwent are essentially few. Plato held that in addition to the visual substance that emerges from the eye to gather information, there was another factor – rays from the objects seen, which blend with those of the eye and thus produce vision. Alexandrian anatomists fixed the seat of vision in the lens, a view that Galen elaborated when he conceived the retina lining the posterior aspect of the lens as a mirror in which the object is reflected and thence transmitted along the optic nerve to the brain.

A radical break from these views were those of the Atomists who conceived vision as the result of small particles constantly detaching themselves from objects and flying in all directions, including the eye. Aristotle likewise approached the modern conception when he insisted that things are seen by influences emanating from them, rather than from rays emerging from the eye. But whilst speculation was rife, actual observation was not altogether wanting. Amongst the Alexandrians, Ptolemy in a lost treatise on light, appears to have held with his con-

temporaries that objects are seen by rays emerging from the eye. He taught that distance is judged by the length of the emergent rays, position by their direction, and size by the angle rays subtend on striking an object. More significantly, he recognized binocular vision and diplopia, even to the extent of describing the crossed and uncrossed varieties of double vision.

The nature of the visual spirits that produce vision was defined by Galen as *pneuma*; the pneuma, derived from the brain, fills the space in front of the iris, dilates the pupil and surrounds the lens. Short sight resulted from weakness of the visual spirit; though it passes through the pupil and emerges from the eye it fails to reach an object in the distance. A later writer (Alexander of Aphrodosias, in the third century), argued that the phosphene seen on sustaining a blow on the eye was the result of the pneuma becoming inflamed.

The Arabian renaissance brought uneasy stirrings against the traditional view of vision as the result of energy emanating from the eye. Ar-Razi compiled a monograph: 'On the nature of vision: wherein is shown that the Eyes are not Radiators of light'. But it was not till Alhazen (Ibn al-Haitam), in the eleventh century, that a valid challenge emerged. Basing himself on the geometry and physics of his day he solved a number of optical problems, conclusively establishing the view that objects are seen by rays passing from them towards the eye and not in the reverse direction as was believed. With Alhazen begins not only modern physiological optics but modern optics too, and during the Western Middle Ages Robert Grosseteste, Roger Bacon, John de Peckham and Vitello contributed to the newer optics.

The more substantial optics that thus emerged had little effect on ophthalmic physiology. The gulf between the academically minded physicists and the itinerant oculists of the Middle Ages was too vast to be easily bridged, and even to

the physicians the newer optics percolated but slowly. Maurolycus, Leonardo da Vinci, Plater and Porta are names of significance in this interregnum, in which slowly the eye was coming to be regarded as an optical instrument, subservient to the same laws of physics as lenses. Da Vinci and Porta haltingly reached towards the conception of a *camera obscura*. Porta's statement is worth quoting, both for its formulation of the newer view on the nature of vision and for its retention of the fallacious physiology of Galen: 'As objects illuminated by the sun send their light through a narrow hole in the window-shutter upon a paper placed opposite, exactly so does light, passing through the hole of the pupil, produce images of objects looked at upon the crystalline lens.' That the retina and not the lens was the receiving plate of the eye was held by Plater, but not till Kepler were his views harmonized with those of Porta.

Kepler's work is the consummation of that of Alhazen. With Kepler the eye becomes an optical apparatus obeying the laws indicated by the Arabian. The *camera obscura* conception becomes complete – the retina is the receiving plate, the lens and cornea are refracting media. With an understanding of the optical properties of the eye came the appreciation of the significance of myopia and the rational use of glasses.

A number of problems pressed for solution as a result of Kepler's work. The precise optics involved acceptance of an inverted image on the retina. That this indeed occurs was shown shortly afterwards by the Jesuit Father Scheiner in an experiment in which a window was made in the posterior pole of an animal eye. Scheiner was also responsible for measuring the indices of refraction of the components of the eye; he measured the radius of curvature of the cornea by the simple expedient of placing glass spheres of known curvature alongside the cornea and finding which sphere gave an image of equal

size to the image of a window seen on the cornea. But apart from the accurate physical measurements that were being undertaken, the conception of the eye as an optical instrument precipitated the problem of accommodation. Obviously if the eye could register impressions of objects both near and far, it was a dynamic and not a static optical apparatus. Accommodation was thus recognized as a property of the healthy eye, and the problem of accommodation formulated by Kepler was to baffle physiologists for well over two centuries.

Kepler himself held that accommodation was effected by the ciliary processes either through a change in the form of the eye, the anteroposterior diameter becoming shorter and the horizontal diameter wider, thus bringing the retina nearer to the lens, or alternatively that the lens was moved from its position. Further possibilities were advanced by other observers. Descartes held that in addition to change in the length of the eye, which he regarded as due to the action of the extraocular muscles, there were also changes in the form of the lens, induced by the ciliary processes. His views as to changes in the form of the lens were supported by William Briggs. Others (de la Hire, Haller) sought to explain accommodation on the basis of Scheiner's observation that the pupil contracts during accommodation; it was held that the elimination of diffusion circles by contraction of the pupil would account for the clear vision of near objects in accommodation – a view supported by the fact that objects are seen more clearly through a pin-hole. Changes in the curvature of the cornea were held responsible by Albinus and Ramsden. Supporting the theory that accommodation is produced by changes in the curvature of the lens, Jurin advanced the hypothesis that such changes were brought about by displacement of the Morgagnian fluid of the lens. Independent contractility of the lens was postulated amongst other by Leeuwenhoek and Thomas Young, who regarded the lens as a muscular structure. Young's

laborious investigation on the structure of the lens failed to demonstrate nerve fibres in it, though his 'full conviction of their existence' was unshaken. In spite of his faulty anatomy Young nevertheless solved the problem as to the seat of accommodation by experiments on his own eyes. He dismissed the cornea from consideration by finding that his accommodation was unaffected when he eliminated the cornea optically. This he did by using a forerunner of the modern contact glass – a weak objective lens of a microscope placed before the eye with water between the objective and the cornea. Young, who had very prominent eyes, further disproved that the eye elongates during accommodation by clamping his own eye between two rings, one placed on the anterior surface of the eye, turned inwards as much as possible, and the other, the ring of a small key, thrust on the external side between the orbit and the globe till the phosphene reached the fovea. Thus clamped, the eye could not elongate during accommodation, and as this was not abolished and as furthermore the size of the phosphene did not change during accommodation – as it would have done if the eye had elongated – he held that accommodation is independent of elongation. Young concluded in favour of regarding changes in the surface of the lens rather than in its position as the responsible factor. As additional proof that the lens was the seat of accommodation he pointed to the fact, stressed before him by Porterfield, that in aphakia accommodation is abolished. The mechanism whereby the lens surfaces changed he could not elucidate. The discovery of the ciliary muscle had to wait another fifty years, and it was left to Helmholtz by means of his phakoscope to demonstrate the actual changes in the curvature of the lens and to describe the nature of accommodation. In doing so Helmholtz rescued Young's work from under a spate of theories which continued to flourish in spite of Young's demonstration of their untenability.

Another consummation of the work of Alhazen came with Donders. The rather florid judgment of Hirschberg is not an exaggeration: 'Donders' work is of that wonderful clearness that is seen in an alpine scene under a marine blue sky; each chapter is like a self-contained valley: the writing is polished, penetrating and permanent'. Original observations are not lacking, but even more significant is the critical analysis which pervades his work. Before Donders refractive errors were classified according to the correcting lens required; myopia was the condition in which concave lenses were needed, presbyopia in which convex lenses were required. The puzzling thing about 'presbyopia' was its occasional occurrence in young people – 'old sight of young people'. Many before Donders had conceived of hypermetropia; many too had realized that disturbances in accommodation could result in defective vision, but it was Donders who separated clearly errors of refraction from those of accommodation. It was he who introduced hypermetropia as the antithesis of myopia, and distinct from presbyopia, thus demolishing the 'old sight of young people'.

The concept and the term emmetropia also came from him. Many years before Donders, Thomas Young had described astigmatism, but a mass of hazy notions on the subject awaited crystallization in Donders' writings.

Apart from clear classification, the clinical aspect of refractive errors was well elucidated. Donders introduced the classical formula for determining the range of accommodation; conceiving presbyopia as a diminution of the power of accommodation he established the absolute, binocular and relative range of accommodation, and also showed that the correction of presbyopia relieves headache. Myopia was critically considered from analysis of thousands of cases, and the problems it presented as to heredity, close work, ophthalmoscopic appearances, anatomy, symptoms and treatment

were clearly brought out. The innovations since 1864 when Donders' *Anomalies of Refraction and Accommodation* was published, have added or detracted little of material value, though the full benefit of his work could not be realized till the introduction of the shadow test by Cuignet in 1873 and by the use of mydriatics. The new outlook that Donders contributed to ophthalmology is well illustrated by the fate of 'asthenopia', a term first introduced by Mackenzie in 1830. To Mackenzie, who regarded the symptoms as due to retinal exhaustion, the condition was of such serious import that giving up work and long sea-voyages were considered appropriate treatment. Since Donders, asthenopia has come to stand for one of the minor ailments.

In the century following Kepler's, attention was being given to the fundamental physiology of the eye. Mariotte had already discovered the blind spot in 1668, and Briggs the optic papilla in 1676; Porterfield in 1759 showed that the blind spot was indeed the entry of the optic nerve. Porterfield further insisted that the retina and not the choroid, as Mariotte believed, was the essential organ of sight. Whilst attention was being given to after-images and the suggestion even advanced that they are the result of fatigue of the retina, these and allied problems were generally regarded as beyond explanation. Porterfield well expressed the contemporary attitude in a passage characteristic of his century: 'The Connection betwixt our Ideas and the Motions excited in the *Retina*, Optic Nerves and *Sensorium* is unknown to us, and seems to depend entirely on the Will of God.' Binocular vision, though Briggs had advanced the theory of corresponding points, was likewise explained in terms of theology; to Porterfield it was reflex act of the soul. It was not till the nineteenth century that progress in these fields of study became established.

Binocular vision began to become intelligible with the introduction of the stereoscope by Wheatstone and with the studies of David Brewster. Studies of the field of vision, though indicated by Thomas Young, did not begin seriously till taken up by von Graefe, working with sheets of paper on which he had drawn radiating lines to act as meridians (1855). The work on colour vision by Helmholtz was likewise a return to Thomas Young.

Ocular movements too had to wait till the nineteenth century for any intensive study. The work of Johan Müller led to the studies by Listing and to the formulation of Listing's law in 1857.

After Helmholtz had proved that not only the optic disc but also the optic tracts were insensitive to light, and Müller had shown that the layer of rods and cones was the recipient element, Weber (1852) drew attention to the exclusive presence of cones at the macula and formulated the theory that the cones alone are the light-receiving elements.

Studies on the nutrition of the globe began with Leber's work in the seventies of the last century, and were soon followed by the work of Priestley Smith on the significance of drainage of intraocular fluids in the normal and glaucomatous eye.

IV. PATHOLOGY

LIKE all pathology, that of Hippocrates was the reflex of the prevailing philosophy. The Ionic school held that there were four elements: water, fire, earth and air, and that these gave to matter its four cardinal properties: moisture, warmth, dryness and coldness. This was translated in terms of physiology as four cardinal humours: blood, mucus, yellow bile and black bile. Health resulted from the proper and proportionate admixture of these humours in the body; disease implied a disturbed balance. Left to itself the disturbance ran through three stages – *crudity*, when the disturbance occurs, *coction*, when the body prepares to expel the disordered humours, and *crisis*, when that process takes place. In addition to these general conceptions, there was a sort of special pathology which postulated the existence of seven injurious humours passing from the brain to the tissues, and constituting the catarrhal process. One humour passed into the nose and two affected the eyes, one of these producing the discharge in ophthalmias and the other affecting vision without producing an external discharge.

This fanciful stuff apart, the Hippocratic school was responsible for some sound observations. They recognized not only the inflamed eye but such external conditions as could be appreciated without any detailed knowledge of anatomy; they were acquainted with such things as chalazion, pterygium, ectropion, entropion, trichiasis, nystagmus, and squint. Though no detailed clinical appreciation was achieved, it is characteristic of their powers of observation that they recognized blindness following haemorrhage – a close approach to the blindness from optic atrophy consequent on haematemesis and metrorrhagia.

Alexandrian ophthalmology, as preserved by the writings of Celsus, shows considerable advance in the recognition of

disease. A distinction is made between moist and dry ophthalmia (ophthalmia and xerophthalmia), and a good account of trachoma is given under the term *aspritudo*, the name trachoma not being introduced till three centuries later by Severus. A number of additional external conditions, such as proptosis and lagophthalmos, are also described, and the information is more definite.

The ocular pathology of Galen marked but little progress. It was more systematized, and recognized eye disease as resulting from affections of (1) the crystalline body, the essential organ of sight; (2) the brain and visual nerve, involving disturbances in the visual spirits proceeding from the brain along the visual nerve to the essential organ of sight; and (3) of other parts of the eye distinct from the essential organ of sight. Disease of the crystalline is shown by glaucoma, the greenish discoloration being produced by drying of the lens; the condition is incurable, affecting as it does the essential organ of sight. Disease of the brain and visual nerve is shown typically by cataract, the corrupt humour settling in front of the lens. Disease of other parts of the eye affects the pupil or the space between the pupil and the lens, the aqueous and pneuma being at fault.

In the succeeding centuries this doctrine became dogma. The Byzantine commentators added little of their own and the Arabians could not break away from the concept of ophthalmias and of corrupt humours settling in the eye, though their clinicians were responsible for some remarkable observations. Thus Rhazes (Ar-Razi) recognized the pupil reaction to light, whilst Sams-addin described 'headache of the pupil' – probably the first, though vague, recognition of acute glaucoma; pannus too is first described in Arabian writings.

The weary process of commentaries upon commentaries dragged on even after the Renaissance. Except for some clearer definition, little had been gained in the meantime.

The humoral theory of disease underlay the separation of blindness into two varieties, *gutta serena* and *gutta opaqua*. In the first the pupil was unclouded by the morbid humour, in the second it was affected. *Gutta serena* and *suffusio nigra* were sometimes used in contrast, but more frequently as synonymous with glaucoma, blindness without an opaque pupil. That no real understanding underlay this classification is obvious enough.

The seventeenth century saw the overthrow of the theoretical basis of Galen's ophthalmology, but clinical ophthalmology hardly escaped from the stranglehold of his theories and teaching. The new anatomy and physiological optics permeated but slowly, and it was left to a few French workers in the succeeding century to evolve new clinical conceptions. The recognition of the seat of cataract was the opening of the chapter; this brought new views as to the nature of glaucoma. And equally significant, even though it led to a blind alley, was the rise of a new orientation in the description of disease-processes. What basis of purely anatomical description there was in Galen – descriptions such as pterygium and hypopyon – were taken over, and attempts were made to describe the ophthalmias in terms of aetiology. The iatrophysicists had too evanescent an influence to affect ophthalmology, but the succeeding iatrochemical school described ocular disease in terms of chemical disturbances, or diatheses. Thus arose conceptions like catarrhal, rheumatic, arthritic, scrofulous, gouty, haemorrhoidal and cancerous ophthalmia. Though this led to much clinical observation, and the incidental isolation of such things as gonorrhoeal ophthalmia, ultimately this activity produced a maze of fantastic descriptions with no basis in fact. It reached its climax with Beer's classical textbook published at the beginning of the succeeding century. During this process of evolution the ophthalmias came to be recognized as consisting of external and internal varieties, the internal

varieties following the same sort of classification as had already been applied to the external ophthalmias.

It remained for the nineteenth century to demolish all this. And whilst in the eighteenth century the pioneer work was done almost exclusively in France, the trend of newer thought came from England by the publication in 1808–18 of Wardrop's *Essays on the Morbid Anatomy of the Human Eye*. In describing disease Wardrop broke away from hypothesis, and in the true Hippocratic manner concentrated on observation and fact. Though he began before the compound microscope had come into use, he dealt with ocular lesions on a strictly anatomical basis, speaking of inflammation of the cornea, iris, choroid and so on. He introduced the term keratitis, though the credit for the term iritis belongs to Schmidt, who used it in 1801. Wardrop's efforts attracted rather more attention in France than in his native country, for English ophthalmology was largely dominated by Beer; and Mackenzie, with his classical textbook of 1830, helped to perpetuate the system of Beer and of other Teutonic writers. Yet the anatomical classification was slowly gaining ground, some of Wardrop's excesses naturally being modified in the process. Thus hyalitis, descemetitis, and capsulitis came to be dropped. In 1836 Schindler described fully several forms of keratitis, including interstitial keratitis. Equally significant was the slow disintegration of the conception of internal ophthalmia. The term cyclitis was first used in 1844 (Tavignot), and though such monstrosities as aquo-capsulitis and cristallino-capsulitis were introduced and lingered for some time, the generalization of all intra-ocular disease as one had become a matter of the past.

All through these years progress in observation was also being made. The charlatan Chevalier Taylor described keratoconus, though preceded in this by Duddell; Beer corrected Scarpa's error in regarding pannus as a similar condition to pterygium, whilst a few years later Fabini (1830)

drew attention to the fact that pannus is often present in trachoma. Blindness in association with nephritis was observed even before the classical description by Bright.

The demolition of internal ophthalmia and of the fantastic aetiology of disease could not however be achieved till the coming of the ophthalmoscope for the one and the rise of bacteriology for the other.

Bacteriology, whilst overwhelming much aetiological fantasy, established definitely such things as the gonorrhoeal nature of ophthalmia of the newborn, which was well described and recognized as of venereal origin by Ware in 1795, whilst Benjamin Gibson, in 1808, had clearly indicated its mode of transmission and the means for prevention. His teaching was, however, largely ignored, and ophthalmia neonatorum continued to be explained as the effect of sunlight on the eyes of the newborn, as the result of compression of the infant's head, as the consequence of cold baptismal water, whilst Mackenzie attributed it to the soap with which the newborn infant was washed getting into its eyes.

Bacteriology did not, however, resolve all the puzzles of external ophthalmia any more than the ophthalmoscope gave final answers to those of the internal ophthalmias. In the external ophthalmias non-bacterial reactions remained, such as trachoma and scrophulous ophthalmia. The recognition of virus disease had yet to come for the understanding of trachoma, whilst, prior to the advent of bacteriology, Jonathan Hutchinson, in 1858, had already distinguished interstitial keratitis from the mass of scrophulous ophthalmia, recognizing it as one of the tetrad of stigmata of congenital syphilis. The understanding of the nature of phlyctenular ophthalmia had to wait for the development of the conception of allergy introduced by von Pirquet (1903).

Likewise the ophthalmoscope, whilst bringing forward a wealth of new clinical conceptions – such as retinitis pigmentosa

with its genetic character, glioma of the retina and sarcoma of the choroid with their malignant course, retinal detachment with its slowly disintegrative effect on the globe, and retinal and vitreous lesions consequent on general disturbances – failed to elucidate the nature of the various forms of uveitis. These inflammatory reactions, like scrophulous ophthalmia, are not directly, if at all, of bacterial origin and commemorate, under new names, the conception of internal ophthalmia just as names like renal retinitis for a frankly non-inflammatory lesion are verbal monuments to views no longer valid.

The work of Cunier in publishing the extensive Nougaret pedigree of inherited nightblindness (1838) and of Liebreich in recognizing the genetic basis of retinitis pigmentosa (1861) paved the way for the present-day development of ocular genetics initiated at the beginning of this century by Nettleship and Usher.

V. CATARACT

IN the first authentic document on the subject, the writings of Celsus, there is a complete teaching on the pathology and treatment of cataract. The preceding Hippocratic writings are silent on the subject, so that the Alexandrian school must have developed the subject to the advanced level seen in Celsus. What exactly the Alexandrians did and where they found the basis for their studies, is a matter of conjecture. It is possible that the operation for depression was known in India since early days, but the evidence that it was known in Egypt and Babylon is more than doubtful. Celsus' account of cataract and its treatment was indeed the teaching that persisted till the eighteenth century with hardly any modification. The sudden eruption of a complete system of pathology and treatment from out of a historical void is but one of the many strange things in the history of cataract.

Cataract as a name is of comparatively recent origin. It arose out of mediaeval Latin translations of Arabic writings and was a sort of shorthand term for expressing the pathology of the condition – humour that flowed down into the eye. The older Latin name was *suffusio* and the Greek name, *hypochyma*, both having the same humoral implication; but these names were not revived to any extent when, with the Renaissance, men turned from translations from the Arabic to the original classical sources.

Suffusio with Celsus stood for that form of blindness which could be relieved, as opposed to glaucoma which was a form of incurable blindness. In *suffusio* corrupt, inspissated humour collected in the *locus vacuus* between the pupil and the lens, thus obstructing the visual spirits. By clearing this empty space vision could be restored. The obstruction caused by the *suffusio* could be removed in the early stages by medicinal

treatment, but when fully formed only by operative displacement into a part of the eye other than the front of the lens. The operation involved entering a sharp, but not too slender needle into the eye and when resistance was felt on touching the *suffusio*, this structure was gently worked downwards away from the pupil. If it did not stay down, the *suffusio* had to be broken up in pieces and these fragments were then depressed. Celsus gives a detailed account of the pre- and post-operative treatment. Incidentally, a later Roman writer attributed the development of this operation to the casual observation that vision was restored to a goat, blind from cataract, when it ran its eye on to a thorn.

The conception of cataract as inspissated humour in front of the lens persisted with Galen, in whose anatomy there was no *locus vacuus*. During Arabian times the conception became even more firmly rooted and the central position of the lens in the anatomy of Vesalius is evidence of the firmness with which the belief was held. The epoch-making work of Kepler and his forerunners in dethroning the lens from its position as the essential organ of vision had no immediate result on the teaching as to the nature of cataract. At about the middle of the seventeenth century more than one observer began to question whether cataract was not indeed an affection of the lens, but the rooted belief that glaucoma was due to drying of the lens was a great obstacle to the resolution of these questions and doubts. Characteristic of these doubts is the observation by Dechales that the reason why strong convex lenses are needed by patients operated on for cataract must be that the secretion destroys the spherical shape of the lens. By actual demonstration of an opaque lens in cataract, Rolfinck in 1656 crystallized a considerable amount of discussion and teaching by both physicists and oculists. About thirty years later Maître-Jan noted that it was not a thin membrane but a thick rounded body that was displaced when on two

occasions he chanced to displace the cataract into the anterior chamber instead of into the vitreous. He further had the opportunity of examining the eyes of patients whose cataracts he had couched and found that it was the lens itself that was displaced. He concluded that cataract and glaucoma were indeed one and the same disease, but the one was curable and the other not.

These observations passed unnoted. When Brisseau, a young man at the beginning of his career, rediscovered in 1705 all this for himself, his friend and teacher Duverney advised him against publication, if he did not wish to jeopardize his future. However, his findings went forward to the *Académie Royale des Sciences*, through the intermediary of a member of it, only to be told that his views had made little impression. Brisseau had nevertheless succeeded in raising a controversy – a thing in which his predecessors had failed. Maître-Jan came forward with his own proofs as to the truth of the new conception, and Brisseau himself advanced further proof. De la Hire and Mery were prominent in the opposition, whilst Petit supported Brisseau. However, in searching for conclusive evidence against Brisseau, Mery convinced himself of the error of his own views and came out in the Academy strongly in favour of the new teaching. Indeed in the Academy the battle was soon won, but for years the repercussions distracted the rest of Europe. Boerhaave, Morgagni, Valsalva and Cheselden were amongst the supporters of the new school, whilst prominent amongst distinguished opponents was that brilliant charlatan, Thomas Woolhouse.

The acceptance of the new pathology precipitated acutely the problem of glaucoma, for glaucoma was held to be a disease of the lens. It also forced attention to such conditions as obscured the pupil and were not cataract. It thus involved a new pathology as to the causes and treatment of blindness.

Hardly had the *furore* caused by this controversy died down before another storm broke which was destined to last throughout the second half of the eighteenth century and to be prolonged well into the nineteenth. Brisseau died in 1743. Five years later Daviel published his account of extraction of the lens.

The radical treatment of cataract as practised today is essentially the method of Daviel. But previous attempts at radical treatment were not wanting. Indeed there are puzzling passages in the older writers which would lead one to believe that extraction had some transient vogue in ancient days. There is the bleak passage in Galen which speaks of some who, instead of displacing the cataract to a site where it is less troublesome than in front of the lens, 'have attempted to extract it, as I shall show in the book dealing with operations'. This book is lost and the later Greek writers do not refer to the operation. Roundabout information comes from Arabian sources. Salah-ad-din reports Razi as saying that according to Antyllos some divide the lower part of the pupil and extract the cataract, the procedure being possible only with thin cataracts, as with thick cataracts the humour [aqueous] also escapes.

These references to extraction in all probability implied some form of evacuation. A much more significant attempt at the radical removal of the cataract is due to the Arabian, Ammar, who elaborated the operation of suction. The introduction of a glass tube through a corneal incision for removing cataract is also referred to in the passage 'according to Antyllos'. Arabian practitioners before Ammar certainly practised it, but it was left to Ammar to devise a hollow needle introduced through the sclerotic, thus avoiding an incision into the anterior chamber and consequent loss of aqueous, which was regarded as a calamity. Ammar's operation failed to gain adherents in the Western Caliphate and in Christendom.

In the East it found a readier reception. In Western Europe the operation had to be rediscovered during the last century.

Surgical treatment of cataract at the time of Daviel was therefore confined to depression. Breaking up the lens piecemeal, to induce depression in such cases where the lens would not stay down, was a course adopted only as a matter of necessity. Daviel's cataract operation was therefore as marked an innovation in treatment as the work of Maître-Jan and Brisseau had been in pathology.

Before Daviel the possibility of extraction was slowly maturing. When Mery recognized the truth of Brisseau's work he also saw that it might be possible to extract the opaque lens by an incision into the eye. The lens was actually extracted by St. Yves in 1722, but it was extraction of a lens which had become displaced into the anterior chamber during an attempt at depression. Piecemeal removal of a broken-up lens, particles of which had floated into the anterior chamber, was also carried out by Petit; and it was a similar unplanned emergency procedure that started Daviel on his planned extraction. What had been forced on him by accident and, incidentally, had proved utterly unsuccessful, he repeated deliberately in a second case – deliberately making an opening through the cornea and removing the lens piecemeal. Actual extraction of the lens *en masse* was forced on him in a case in which he failed to couch the cataract. He then 'decided to open the lower portion of the cornea in order to get my needle the more effectively into the posterior chamber. Then for a long time I held the cornea by a small forceps and brought forth the lens'. A year later (1748) he published his account, but it was some years before he finally decided in favour of extraction to the exclusion of depression.

Daviel's operation consisted of a corneal incision near the limbus below, made by puncture with a sharp curved needle, enlargement of this puncture to the right and left with a blunt

curved needle, and completion of the incision to the right and left with curved, convex scissors; the incision having been made, a spatula was introduced into the eye, and while it held the cornea away from the lens, the sharp needle was used for opening the capsule; the spatula was next passed between the iris and lens to free any adhesions; gentle pressure to dislodge the cataract completed the operation.

The operation was taken up enthusiastically – but only for a brief space. Everywhere influential support for the older operation became consolidated, and new methods for couching were developed. During the hundred years in which Daviel's operation was on trial many modifications of an ephemeral vogue were introduced. The complicated incision practised by Daviel soon enough gave way to a single incision by a knife, special patterns being introduced by almost every operator. At an early stage incision at the upper limbus was proposed, but this gave way to a modified incision lower down. Other modifications aimed at different varieties of corneal incision, the variations ranging from semicircular to triangular. To obviate suppuration and promote better healing scleral incisions were advocated. This was partly the underlying principle of von Graefe's linear incision, an operation that was soon given up because of cyclitis and sympathetic ophthalmia which so frequently followed. Until the advent of the present-day methods of intracapsular extractions – made possible by the developments in local anaesthesia – the one generally accepted radical modification of Daviel's operation was Mooren's preliminary iridectomy, introduced in 1864.

VI. GLAUCOMA

THE term glaucoma goes back to Hippocratic times. Its meaning is disputed; generally accepted to signify greenish, like the colour of sea-water, Hirschberg has shown that it is much more likely to mean bluish. It would appear that in Hippocratic writings *hypochyma* and *glaucosis* were synonyms, and both vaguely referred to cataract. It is only with later Greek writers that a distinction was made between the two, glaucoma becoming the incurable condition as opposed to hypochyma which was curable, though not always so. Glaucoma came also to stand for an affection of the lens itself, as opposed to cataract, which was a perverted humour in front of the lens. It is possible that the term was applied indiscriminately to all blindness not considered as cataract and in which the pupil changed its colour. Absolute glaucoma, with its 'green cataract', as well as pupillary exudates were probably included. (Whatever else it may have stood for, it did not stand for the chronic glaucoma of today; for in this, as well as in the bulk of acute glaucoma, the discoloration of the pupil is not a striking feature.) In any case it would only be the terminal stages of chronic glaucoma that would be recognized and this no doubt passed as amblyopia, amaurosis or, in later days, as *suffusio nigra* or *gutta serena*.

Glaucoma, in antiquity, therefore hardly stood for any definite entity. But the term created a problem in pathology when Brisseau showed that cataract was a disorder of the lens itself. Some, like Maître-Jan, were content to let both diseases reside in the lens; others, like Brisseau, monopolized the lens for cataract and satisfied themselves that glaucoma was an affection of the vitreous, a view that led to much anatomical work to show what exactly the changes in the vitreous were. Vitreous fluidity, vitreous floaters and all sorts of vitreous

abnormalities were brought forward as evidence for that view, and the discussions on the subject still persisted towards the middle of the last century. In these discussions other tissues were incriminated; Mackenzie, amongst others, blamed varicosity of the choroid.

All these discussions were of necessity futile, for they centred round a word rather than round a pathological entity. The essential feature of glaucoma – hypertension – was not generally recognized till about 1840, and even so, recognition only extended to acute glaucoma and absolute glaucoma. It was in fact a new entity that was being built up – a disease in which the cardinal sign was increased tension, and in which the name glaucoma had come to be a meaningless label. The problem was no longer why the pupil was discoloured, but why the tension was increased.

The first clear recognition of absolute glaucoma came with Richard Banister in 1622. Discussing the differential diagnosis between curable cataract and incurable *gutta serena* in which 'the humour settled in the hollow nerves, be growne to any solid or hard substance, it is not possible to be cured' he gives 'foure wayes', one of which is 'if one feele the Eye by rubbing upon the Eie-lids, that the Eye be growne more solid and hard than naturally it should be'. The three other tests were no different from those in common use at that time for determining the curability of cataract. Banister's tetrad – long duration, no perception of light, increased hardness and no dilatation of the pupil [?on screening the sound eye] – is a passable account of absolute glaucoma. His teaching, however, failed to attract any attention. Hardness of the eye is next found in the literature a hundred and twenty-three years later, in J. Z. Platner, with nothing like Banister's completeness. At the beginning of the nineteenth century it was rediscovered; it appears in a number of books printed around 1820, and in Mackenzie's classical textbook of 1830 it is given explicitly

in the differential diagnosis between glaucomatous amaurosis and cataract.

Acute glaucoma, though not under that name, has a more considerable antiquity. The Arabian Sams-ad-din recognized it as a distinct entity in the amorphous mass of ophthalmias. He described under 'Migraine of the eye, also known as Headache of the pupil' a condition in which there is a deep-seated pain in the eye associated with hemicrania and dullness of the humours; the condition is sometimes followed by cataract and dilatation of the pupil; if it becomes chronic, tenseness of the eye and poor vision supervene. This conception of a distinct disease does not, however, seem to have prospered. Though tentative attempts at the recognition of acute glaucoma were made by several writers in the eighteenth century, it is not till 1813 that a really convincing description occurs – an account by Beer. A form of iritis is differentiated from the other varieties by its distinctive symptoms and in that it ends in blindness, a greenish hue (glaucoma), a dilated pupil and cataract – a tolerable description of the terminal stage of neglected acute glaucoma, even though the cardinal sign of hypertension is missing. In his ambitious attempt to describe eye conditions on a basis of causation, Beer named this acute condition as iritis of gouty origin. Rainbow colours and hardness of the eye in an affection termed glaucoma appear five years later in a description by Demours. Subsequent publications speak of arthritic iritis (and ophthalmitis), as well as glaucoma, in describing conditions which appear to have been the same, apart from the presence of the greenish pupil reflex in the latter. The first to recognize that these two disorders were identical was Sir William Lawrence; he considered glaucoma 'to be merely a chronic form of the same inflammation as the arthritic inflammation affecting the posterior coats of the eye'. It was also he who introduced the term of acute glaucoma (1829).

Lawrence did not link up acute glaucoma with what we now call chronic glaucoma, but with what now passes as absolute glaucoma – their link being not hypertension, but the greenish discoloration. It was only when the ophthalmoscope had revealed cupping of the disc that hypertension as the essential feature of glaucoma was finally realized. Even so, von Graefe in 1857 missed chronic glaucoma; he speaks of acute, chronic [i.e. absolute], and secondary glaucoma and of amaurosis with excavation of the disc. Not till Donders recognized this last group as glaucoma simplex was the unifying conception achieved, a teaching that gained greatly from Bowman's simple numerical notation in recording the findings of digital measurement of tension.

When the older writers spoke of the incurability of glaucoma, they were right not only by their standards but by our own, for the condition they discussed was absolute glaucoma. Acute glaucoma, in contra-distinction to chronic glaucoma, only emerged after 1830, and that too must have been incurable, for only very severe attacks would be recognized as glaucoma and the treatment would not improve matters, for it was the same as for iritis. Till 1857, when von Graefe introduced iridectomy for acute glaucoma, the diagnosis was indeed tantamount to a sentence of blindness, for even relief from miotics was unknown till about 1875. Not infrequently matters must have been made worse by treatment, for belladonna was used.

Iridectomy for acute glaucoma had no triumphal reception, and not altogether without reason. The rationale of the operation was not only then, but is even now, rather vague. Von Graefe was led to the operation in the belief that staphylomata of the cornea regressed after iridectomy, presumably because of lowering of tension. To not a few surgeons operative interference meant adding trauma to an already markedly diseased eye. Feeling ran high and arguments became acrimonious.

When the collective experience of the profession had established the value of the operation, discussion ranged as to its mode of action. To some the favourable results were caused by a filtering scar induced by the iridectomy, and this led to the various sclerectomies having filtration as their object.

The cause of the increased intra-ocular pressure was seen by von Graefe in a serous choroiditis increasing the watery contents of the eye. To Donders it was due to an increased secretion of the choroid. Stellwag regarded it as the result of increased pressure in the ocular circulation, whilst Priestley Smith stressed faulty excretion rather than secretion, the immediate cause being abnormalities in the angle of the anterior chamber.

VII. THERAPEUTICS

IN a previously unknown Australian island Captain Cook found a woman rubbing with a wooden stick the everted eyelids of a child. This primitive method of treating roughness of the palpebral conjunctiva seems to have a remote antiquity, and is one of the few procedures of Hippocratic ophthalmology that has persisted. Friction to the everted lid was applied by means of rough wool wrapped round a wooden spindle, the process being kept up till a thin sanguineous fluid exuded. This treatment was followed by local applications, generally containing copper.

Of the more ambitious systems of treatment based on Hippocratic pathology little has been left. That pathology with its crudity, coction and crisis of humours led to inactivity when it did not lead to drastic interference. In acute diseases of the eye, local remedies were avoided, and reliance placed entirely on measures influencing the humoral changes. Restriction in diet and hot foot-baths were amongst the most common, but every means that would draw the morbid humour away from the eye was employed: irritant gargles, cupping, venesection, cauterization of the blood-vessels in the neighbourhood of the eye, multiple incisions going down to the bone, and even trephining of the skull to evacuate the humours. For chronic conditions, local applications containing ingredients well recognized in the more ancient civilization of Egypt were freely used – metals and spices as well as human milk.

Alexandrian therapeutics were considerably more advanced. Local treatment for acute conditions was not only recognized but highly developed, the means employed being collyria. Unlike the modern application, the collyrium was a solid medication, made up in cakes of which gum was the basis.

Before use a fragment of a cake was dissolved in water, oil, milk of woman, urine, bile or saliva. There was an endless number of these preparations, and the secret of their composition was jealously guarded. Crude lettering embossed by metal or stone stamps, of which many have been recovered in excavations, gave the name of the collyrium, of the maker, and indications for its use. The polypharmacy of the Romans is well reflected in the composition of collyria, with recorded ingredients. The collyrium of Hermon recorded by Celsus contained no less than 21 substances, and the multitude of collyria he recommended for different conditions indicate a considerable, even if uncritical, therapeutic specialization.

In addition to collyria, the Hippocratic methods of treatment were also pursued. But it was the surgery of the period that constituted a real advance. As elaborated by Galen and his commentators it supplied a rather wide range of operative treatment. Procedures for entropion and trichiasis were perfected ; and an approach to the modern method of treating ectropion was made by Antyllos, as recorded by Paulus Aegineta: a triangular piece was excised from throughout the whole thickness of the lid. Operations were also evolved for lagophthalmos, tumours of the lids, 'aegylops' (swellings at the inner angle), ankyloblepharon, symblepharon, pterygium and panophthalmitis. Rather complicated sutures for the cure of staphyloma of the cornea with or without resection were recorded by successive writers from Celsus onwards, whilst for hypopyon incision of the cornea and paracentesis were described by Galen, who also records that a certain Justus cures hypopyon by shaking the patient's head. That the Romans had a full theory and practice of cataract has already been mentioned.

After Galen superstition began to creep back into therapeutics, and with it came revivals of Egyptian and Babylonian treatment by meconium, faeces and similar substances.

Amulets, charms and invocations figure largely in Aetius and his successors. Invoking the Deity was a usual introduction in the Arabian writings which, however, are not devoid of useful innovations, suction for cataract and peritomy in pannus being the most significant.

Astrology and its sister-study of herbs added encumbrances to the load of therapeutic measures under which ophthalmology was labouring. Towards the end of the sixteenth century Georg Bartisch, the father of German ophthalmology, in the first book on ophthalmology that appeared in the vernacular, devoted chapters to sorcery, white magic and black magic, though it is fair to add that Guillemeau's book – in French – appearing two years later (1585) is not disfigured in this manner. The crowning achievement in therapeutics during these long years of stagnation was the introduction of spectacles towards the end of the thirteenth century.

It was Bartisch who was responsible for the first surgical innovation that came with the Renaissance, by describing complete excision of the eye. Nearly 50 years later (1627) Fabry employed the magnet for removing a foreign body from the eye, but this procedure received no general consideration till well into the nineteenth century. The seventeenth century was therapeutically sterile. It was left to the eighteenth century to introduce three epoch-making operations – two concerned exclusively with cataract, and the third very largely with it. Early in that century Petit, basing himself on the new anatomy of cataract, described breaking up the lens in soft cataract and leaving it to absorb instead of attempting depression; and the middle of the century saw Daviel's work. But something entirely new, and the opening of a chapter to which the succeeding century added greatly, was the operation for artificial pupil introduced by Cheselden (1729).

Cheselden's operation aimed at making an opening in the iris by a needle introduced through the sclerotic in cases

where the pupil was blocked either congenitally, after inflammation, or after couching for cataract. To a generation which did not know of asepsis, and of atropine in the treatment of the almost inevitable post-operative inflammation, the significance of the operation loomed larger than it does to us. Yet Cheselden's operation was ill-adapted to the purpose it set out to serve. Performed in eyes in which the lens was in situ, it caused traumatic cataract; Cheselden's method of introducing the needle through the sclerotic frequently involved injury to the ciliary body; and, most significant of all, the tear produced by a mere puncture was of transient value in most cases, any opening made contracting down or being filled with exudate before long. Attempts at improving the operation began with Sharp who, in 1740, proposed transfixing cornea and iris by one incision across the anterior chamber. Other modifications aimed at cruciform incisions and at divisions of the sphincter at the pupillary margin. But the operation gradually fell into disrepute and oblivion. In 1801 it was hailed as a new operation when Demours reintroduced it.

Cheselden's operation nevertheless opened a new chapter in the surgery of the iris. His iridotomy led to the development of iridectomy by Joseph Beer in 1798. Though a number of modifications and a variety of specially constructed instruments almost discredited Beer's simple procedure – carried out through a corneal incision made by the Beer knife and completed by withdrawing the iris with forceps and abscising it – Beer's operation came to stay. Intended like Cheselden's for the formation of an artificial pupil, it led in the second half of the nineteenth century to the glaucoma iridectomy of von Graefe, and to its successors.

If the eighteenth century was successful in opening up methods for the conquest of blindness due to lens opacity and occlusion of the pupil, the nineteenth century groped unsuccessfully for the relief of blindness from opaque cornea.

During the eighteenth century tentative attempts were made to resect opaque areas; Erasmus Darwin in 1795 trephined out such areas, hoping to obtain clear cornea on healing. Other attempts aimed at excising a scar and suturing clear cornea, and even at the making of windows in the sclerotic. But the problem which attracted most attention during the first third of the century was complete transplantation of the cornea. Successful enough on rabbits, it failed in man; the lingering discussions on the subject were revived by the suggestion (Nussbaum, 1856) that a small glass lens might be implanted in the cornea. This, too, led to disappointment: successful operation led to irritable eyes. That keratoplasty can succeed only when it is partial – and not total – and when the grafted material is of human origin, has been recognized only recently.

Closely allied to these attempts were the efforts to bring a clear part of the cornea into the line of vision. Optical iridectomy was but one of these; others aimed at iridectomy combined with the newly described operation of tenotomy, to bring the eye into a central position. Tattooing of the cornea was revived by de Wecker in 1872, after a chequered career: it had been practised by Galen, condemned by Aetius, resurrected by Guy de Chauliac in the fourteen century and once again condemned by Maître-Jan in the eighteenth century.

The nineteenth century perfected the operation of enucleation introduced by Bartisch, who incidentally had limited its indications to such massive proptosis that the eye was hideous and could not be concealed. Bonnet in 1841 and White Cooper in 1856 introduced the method of operation as it is practised today, whilst evisceration and exenteration did not come till later.

Excision as a therapeutic measure in sympathetic ophthalmia was the achievement of the second half of the nineteenth century. Sympathetic ophthalmia was first clearly indicated by

Duddell in 1729, in recording that he had seen many cases in which both eyes were lost, though only one was originally injured. But it was not till nearly a hundred years later that any clearer conception was developed, largely by Demours and by Wardrop, the latter drawing attention to the fact that veterinary surgeons destroy the injured eye of a horse with lime or a nail in order that the good eye may be saved. Both the writings of Demours and of Wardrop appeared in 1818, and in both the term sympathetic involvement is employed. The first comprehensive clinical description appeared in the third edition of Mackenzie's textbook (1840), and thereafter the seriousness of the condition and its relationship to injuries and retained foreign bodies was well realized. Wardrop had advocated incision into the cornea and removal of the lens and vitreous of the injured eye as a prophylactic measure, but it was left to Prichard, of Bristol, to introduce, in 1851, excision for that purpose. Only after Critchett had shown, twelve years later, the ineffectiveness of excision once sympathetic inflammation had broken out was the value of Prichard's procedure fully appreciated. Thereafter excision rapidly replaced such methods of treatment as division of the optic nerve, of the ciliary nerves and the operation of iridectomy advocated by von Graefe.

Another procedure that was perfected during the century was the magnet operation. Dixon in 1859 deliberately incised the eye to extract a magnetic foreign body, whilst McKeown in 1874 went further: he explored the eye with the tip of a magnet introduced into the vitreous. Hirschberg a year later invented the electro-magnet.

The crowning achievement of the nineteenth century in ophthalmic surgery was, of course, the operative treatment of glaucoma. But it did much in plastic operations on the lids. Plastic surgery is in no small measure a development of ophthalmology.

It was also left to the nineteenth century to give a clear lead in the treatment of squint and of lacrimal obstruction. Both conditions were known in antiquity, but only vaguely understood.

Squint was the evil eye of mythology and primitive folklore. In Hippocratic writings the fact that it frequently affects parents and children is clearly recognized. An early attempt at treatment is recorded in Paulus Aegineta; this consisted of wearing a mask with two perforations placed centrally before the eyes. It was argued that the squinting eye, finding vision obstructed by the mask, would assume a straight position. Fixing bright objects to the outer side of the in-turning eye was likewise attempted; it was held that the attention which these objects excited would make the eye take up a normal position. Little progress on this was made till well-nigh the nineteenth century. Ambroise Paré, towards the end of the sixteenth century, could only fall back on the method of Paulus. During the eighteenth century squint was regarded as the result of malposition of the cornea or of tilting of the lens. But whilst orthodox practitioners could do nothing, the itinerant Chevalier Taylor undoubtedly put squinting eyes straight. Apparently he had discovered the fact that division of the internal rectus would sometimes straighten the eye. Surrounding his activities with much pomp and mystery, he probably performed subconjunctival tenotomies. At any rate there was always an admiring crowd to shout 'a miracle'. More significant was the work of Buffon. He recognized that the squinting eye generally had poorer vision than the fellow eye, and held that this inequality would render objects confused. His treatment was to cover the good eye, or alternatively to place a convex lens in front of it, whilst the affected eye had a plane or concave lens 'in proportion to the strength or weakness of each eye'.

It was well-nigh a hundred years after Taylor before surgical treatment of squint was to become common heritage.

Tentatively suggested by Anthony White in 1827, and by others, the first successful operation – a myotomy – was performed in 1839 by Dieffenbach. Numerous modifications have followed since his day. And just as Taylor was followed by Buffon, so the surgical treatment of Dieffenbach was followed by the optical treatment of Donders, who in his classical work of 1864 showed not only the existence of hypermetropia in squint, but the frequently unequal degree of it in the two eyes and also the disturbance of balance between accommodation and convergence in hypermetropes. The fusion theory, of which Javal was the main exponent, dates from about the same time.

Lacrimal obstruction has a more prolonged and varied history. Though Galen knew the lacrimal glands, the canaliculi, and drainage into the nose, the pathology of the lacrimal apparatus was ill-understood. Under the term *aegylops* were included all swellings at the inner canthus; and the treatment described by Celsus, Galen and their successors was drastic in the extreme: some form of incision down to the bone and the application of the red-hot cautery was the favourite method. Among the Arabians, Avicenna may be regarded as a pioneer in treatment by probing on account of his suggestion to introduce into a lacrimal fistula probes carrying medications. The Renaissance brought accurate anatomical accounts of the lacrimal apparatus by Vesalius and Fallopius, but it was left for Stahl in the eighteenth century to show that the *aegylops* of antiquity was not an affection of the soft tissue, but the consequence of lacrimal obstruction and inflammation. Following this recognition, lacrimal affections were regarded as being either hydropsia – when regurgitation from the sac could be obtained – or ulcerative, when a lacrimal fistula was present. Anel in 1714 was a voice in the wilderness when he evolved a treatment for lacrimal obstruction, in which probes with an olive eminence were passed into the sac through the upper punctum whilst an astringent lotion was injected through

the lower punctum by a syringe, which, like the probes, was devised by him and still bears his name.

A variety of modifications were evolved. Guide-threads for the introduction of medications into the sac, incision into the sac and catheterization through the incision, retrograde probing, an endless variety of probes, and permanent implantation of tubes, were all suggested or tried at different times. Blizzard proposed the injection of metallic mercury, so that by its very weight it would clear a passage. By the beginning of the nineteenth century Anel's procedure had fallen into oblivion, though search still continued for the perfect method. Various attempts at cauterizing the nasal duct by silver nitrate were tried, whilst sealing the puncta was another procedure that had some vogue. It was Bowman who in 1853 reintroduced probing, employing a graduated series of instruments of comparatively large calibre. Weber advocated forcible dilatation, whilst Critchett used laminaria probes.

Though some sort of excision of the sac was practised in antiquity with its cauterization, it was not till Berlin suggested it in 1868 that excision of the sac came into ophthalmology. Two years earlier Laurence had advocated excision of the lacrimal gland, a procedure first mooted in 1843 by Bernard.

The nineteenth century was also responsible for the introduction of mydriatics and miotics. Mydriatics have indeed the longer history, but their widespread clinical application only came with the second half of the century. For pain in the eyes the Greeks used opium, mandragora and hyoscyamus, a practice strongly condemned by Galen as leading to cataract and other serious complications. But Galen was not above using hyoscyamus as a cosmetic application for the blue-eyed, inducing in them a black pupil. Significant, too, is the observation by Pliny that *anagallis* is used for dilating the pupil before couching operations; this procedure is not mentioned any-

where else in the old literature, and the reference is all the more puzzling as *anagallis* has no mydriatic effect; but in accuracy of details the garrulous Pliny is never too reliable. Whatever vogue mydriatics may have had in Greece and Rome they lost during the succeeding centuries. The rediscovery came towards the end of the eighteenth century. Though John Ray, the Father of Natural History in England, recorded in 1686 his observation that a belladonna leaf applied to a small abscess near the eye had caused dilatation of the pupil, it was not till another century had passed that mydriatics received any attention. This came with the reports of three different observers (Daries, Loder, Reimarus), who independently recorded the mydriatic action of belladonna. Loder in 1796 and Reimarus in 1797 advocated its use to facilitate cataract extraction, a practice that was adopted in England by Paget of Leicester in 1801 and John Cunningham Saunders in 1809. Himly in particular did much to study systematically the use and possibilities of mydriatics in ophthalmology, yet it was not till 1831 that atropine was isolated.

The first half of the nineteenth century was satisfied with general treatment of iritis; the use of mydriatics for this condition, though indicated as early as 1805 by Schmidt, did not gain any widespread acceptance. Von Ammon in 1835 could still advise against their use in acute cases, and whilst Desmarres in 1847 strongly recommended belladonna in his textbook, his German translator could only report that the drug causes an increase in the inflammation. It was largely through the advocacy of von Graefe in 1856 that atropine came to occupy its place in modern ophthalmology. No doubt the dispute over the value of atropine was in part the consequence of the failure to distinguish acute and subacute glaucoma from iritis. Even when that differential diagnosis was achieved, the deleterious action of atropine in glaucoma was not appreciated; that only came with von Graefe in 1868.

Miotics have a briefer history. The pharmacology of the calabar bean was studied at Edinburgh in 1846 and 1855, where Thomas Fraser showed its miotic effects in 1862. A year later Argyll Robertson demonstrated its effects on accommodation. In the same year von Graefe studied its antagonistic action to atropine and employed it to facilitate iridectomy in non-inflammatory glaucoma. It was during the succeeding decade, after von Graefe had shown the danger of atropine in glaucoma, that miotics began to be employed as therapeutic agents. Eserine was isolated in 1864 and pilocarpine in 1875.

The coming of asepsis and anaesthesia influenced ophthalmic surgery no less profoundly than it affected general surgery. Characteristic of the dread of post-operative infection in eye surgery in the pre-aseptic era is the fact that needling was regarded as a more dangerous operation than cataract extraction. In cataract extraction the gush of aqueous helped to carry away infection introduced into the eye by non-sterile instruments; in a needling that corrective was lacking. Chloroform anaesthesia made it possible to dispense with complicated 'cephalostats' which aimed at controlling the patient's head during operation, and when Koller, in 1884, showed the possibilities of cocaine as a local anaesthetic for the eye, immense developments in the operative technique became possible.

VIII. SPECTACLES

LEGEND, scholastic disputes, travellers' tales, local patriotism, and downright fabrications have all encumbered the quest for knowledge on the early history of glasses. Rock glass must have been known in early times, but even manufactured glass has a considerable antiquity. A wall painting at Beni Hasan, which accurately depicts the process of glass blowing, is attributed to the period of the XIth dynasty, though there is no evidence of any manufacture of glass in Egypt till the much later XVIIIth dynasty. References to glass and its manufacture also abound in the Bible. Pliny assigned the origin of glass manufacture to the accidental discovery by Phoenician merchants of a glass-like substance under their cooking pots, which had been supported by blocks of nitron. It is not unlikely that some such accident – the fusion by heat of impure sodium carbonate with sand, started off the quest for a less brittle and more transparent substance than was produced in this manner. The manufacture of glass for the production of vases, mirrors and gems of all sorts had developed into an advanced industry long before Roman times.

Legend has it that St. Jerome (*c.* 340–420 A.D.) invented glasses. The evidence that glasses were known in Roman times is hardly more convincing. Pliny records that '*Nero princeps gladiatorum pugnas spectabat zmaragdo*', and this vague reference to Nero watching gladiatorial contests with an emerald has been read to mean that he used glasses. The emerald may well have had other uses: as a gem, as the sporting of the green colours of the Emperor, or as an amulet – for emeralds were reputed to strengthen the eye. Presumably Nero was shortsighted, but what is known about his sight rather suggests the photophobia of the albino, for which indeed he may have used green glass as a protective. Myopia

and the weak sight of old people were well known to the Romans, but nowhere at that period and for many centuries subsequently is there any reference to glasses. Indeed myopia was regarded as a permanent defect, as is shown by the fact that Roman lawyers considered myopia a *vicium perpetuum*, diminishing the market value of a slave. As for presbyopia, the only way Roman patricians knew of overcoming it was by getting a slave to read to them; medical remedies were known as ineffective.

Travellers' tales have made China the original centre of glasses. The earliest evidence concerning glasses in China dates, however, to a considerably later period than the time they made their appearance in Europe. The Chinese probably learnt about glasses indirectly from Europe through the intermediacy of the inhabitants of Malacca.

Magnifying glasses of a sort were known and may have been used in antiquity. The effect of a glass bowl filled with water in showing up details was recognized, as can be seen from a reference in Seneca. Furthermore, Pliny relates that such bowls were used by physicians for burning. The glass bowl was obviously used as a condensing lens, though it was a wonder to the Romans that cold water should be able to burn. Dimly the biconvex lens was already known.

Alhazen had carried the theory of vision sufficiently far almost to have been able to introduce the use of lenses. But it was left for subsequent centuries actually to achieve it. The first recognition of these possibilities seems to have come with Roger Bacon, as seen from a passage not devoid of gross errors. He discusses the use of segments of spheres and shows that letters and small objects on which they are placed appear magnified. 'For this reason such an instrument is useful to old persons and to those with weak sight, for they can see any letter, however small, if magnified enough'.

The observation that segments of spheres magnify was not original with Bacon; what constitutes an advance is the clear

recognition of their use for old people and those with weak sight. If it was not eyeglasses that Bacon had in mind, he advocated the loupe or magnifying glass, the forerunner of spectacles, and without these the invention of the printing press might have had a more limited effect.

References to glasses begin to crowd at the beginning of the fourteenth century; they must therefore have attracted considerable attention towards the end of the thirteenth century. The first medical reference – and that somewhat deprecatory – is by Bernard Gordon, Professor at Montpellier (1305). He recommends a collyrium of such potency 'that it will enable those whose sight is weak from old age to read without glasses'. Guy de Chauliac (1363) likewise recommends collyria, but adds that when they do not help, recourse should be had to glasses. Collyria were in fact the time-honoured means of strengthening the sight. Ali ben Isa has laid down explicitly that they who do not see in the near, 'a condition which mainly affects old people' should use styptic medicines; whilst those who see well near by but not in the distance, require medicines which give moist nutrition and bring the moist principle to the eye.

Attempts to trace the invention of glasses to a particular person have had little success. Franciscus Redi, a distinguished and learned Professor of Medicine in Pisa, in letters to a friend in 1676, writes that he has a manuscript dated 1299, in the preface of which a reference is made to the recently invented glasses: 'I find myself so oppressed by the years that I no longer have the strength to read or write without the glasses known as spectacles, lately invented for the comfort of the poor old souls who have become weak-sighted'. Redi further quotes from a sermon (1305) by Fra Giordano da Rivalto: 'It is not yet twenty years that the art of making glasses was invented; this enables good sight and is one of the best as well as the most useful of arts that the world possesses'. Fra Giordano resided

together with Fra Alessandro da Spina in the monastery of S. Catherina at Pisa, and Redi extracted from the manuscript chronicle of the monastery two references to Spina. One is an obituary notice, Spina having died in 1313, two years after Fra Giordano: 'Brother Alexander da Spina, a modest and good man, had the capacity to make things he had seen or of which he had heard. He made glasses and freely taught the art to others. Glasses had previously been made by someone else who, however, would not say anything about them'. Another reference in that chronicle speaks in the same tone and to the same effect, emphasizing that in contrast to the secretiveness of the original inventor, da Spina freely communicated the secret of the art he had copied.

Thus whilst Alexander da Spina, a Dominican monk, is generally accepted as the re-inventor of glasses, the original inventor is lost to history. It is in fact doubtful whether there was such a one; it is more probable that the value of glasses was found empirically towards the end of the thirteenth century when use of somewhat plano-convex glass for window-panes became widespread. Bacon, who had the requisite theoretical knowledge, did not apparently get as far as glasses, whilst the claims for Salvino Armato of Florence are largely based on a tombstone inscription in the church of St. Maria Maggiore at Florence which reads: 'Here rests Salvino d'Armato of the Armati of Florence, the inventor of spectacles. God pardon his sins. A.D. 1317'. Domenico Manni, a Florentine antiquary, held that Armato was the secretive inventor spoken of in the references to da Spina. What looked like conclusive evidence for Manni's views was published in 1845 by Caesmaecker of Ghent. A rather lurid story is told of Roger Bacon – incidentally translated into a Belgian – fleeing before Papal wrath and passing on his invention of spectacles to a friend, from whom it was that da Spina heard of glasses. Bacon himself was most anxious not to attract further attention

from the Church, as he was already in heavy disfavour for his other activities. To Hirschberg, this tale, along with its other lurid details, sounded like a bad detective story, and on investigating it he found that though it had been accepted as authentic history it was nothing more than pure invention written by a journalist for its reputed author, an optician.

It was therefore somewhere towards the end of the thirteenth century that glasses came to be introduced. Glasses began to have a vogue towards the middle of the fourteenth century, and painters and sculptors could not resist the temptation to endow biblical figures with these accessories. Glasses were even deemed necessary in the Garden of Eden. Public documents make references to them, and wills dispose carefully of spectacles, for they were still a costly item. It was not till the beginning of the sixteenth century that the concave glass began to be used; Pope Leo X, painted by Raphael between 1517 and 1519, is depicted holding a concave lens, and a number of later references in books abound. But it was not till Kepler (1604) that the whole subject was clearly perceived.

Spectacles were not well received by the oculists. Bartisch scornfully dismisses them; he could not conceive how an eye that does not see well would see better with something in front of it. Even after Kepler, collyria for weak sight prospered. Nevertheless a great deal of practical and useful information was being collected by humble vendors of glasses, and this was well systematized in an unacademic treatise published in Spain in 1623 by Daza de Valdés, 'licentiate and notary of the Inquisition in the City of Seville'. The use of high convex lenses after cataract operations is clearly indicated, whilst a scale of different strengths of reading glasses for different ages is laid down. For a man between 30 and 40, lenses of 2 degrees were needed; for one aged between 70 and 80, four degrees, and for higher ages lenses of five to six degrees. Women required more than double the strength, for not only do they perform

more delicate work, but their eyes are naturally weaker.

Almost down to the middle of the nineteenth century the fitting of glasses was the prerogative of untrained vendors – mostly itinerant, who combined this business with the other occupations usual to pedlars. Oculists took but the slightest interest in the matter, at the most recommending a patient to go to a shop and select the most suitable pair obtainable. The range of choice was of course not wide. The stock in trade consisted of glasses for use after cataract operation, glasses for old sight, glasses for short sight and occasionally glasses for 'old sight of young people.' Astigmatism was not known till Young demonstrated it in his own eyes in 1801; that a correction was possible was not realized till Airy designed a suitable cylindrical lens in 1827. But even so it was not till after Donders and the subsequent introduction of retinoscopy that the correction of astigmatism assumed any tangible practical form.

Indeed, almost until Donders, glasses met with a remarkable hostility. During the earlier part of the nineteenth century there was much opposition largely the result of Beer's attitude to them, for Beer had little more use for them than Bartisch. Weller, in a standard book in 1832, advises against concave lenses if the eye is to be saved from deformation, and is to preserve its ability to become far-sighted after the age of 40. Sichel, another important contemporary writer, sees in concave lenses the cause of old sight, whilst yet another author blames glasses for the development of short sight. Here and there, particularly in England, an isolated voice was raised pleading for the use of glasses. In this connection the charlatan Rowley deserves to be remembered, as also Kitchiner and Lawrence. The trial case was first introduced in 1843, and in the same year Küchler introduced test types for near. Eleven years later Jaeger introduced test types for both near and distance, though it was left to Snellen to put these on a scientific basis. By the use of the ophthalmoscope Jaeger paved the way for

the objective determination of refractive errors, in the development of which the names of Bowman (1859) and Cuignet (1875) stand out. But it was largely the work of Donders that made the problems of refraction and the rational use of glasses part of the ophthalmic creed. A social urge for the study of refractive errors and of presbyopia was supplied by the spread of literacy and the development on a mass scale of the popular newspaper and literature.

The use of prisms also dates from this period. First introduced by Kepler, pioneer work in their clinical application had been carried out by Wells in 1792; yet it was not till Donders in 1847 and especially von Graefe in 1857, showed their value in muscle insufficiency, that any serious attention was given to their possibilities.

The theoretical possibilities of contact lenses were appreciated by Herschell, the astronomer, in 1827 as can be seen from his remarks in a discussion on Airy's paper on cylindrical lenses. Fifty years later several observers independently advocated their use for keratoconus and myopia, and obtained passable experimental shells made from blown glass. The manufacture of consistent standardized lenses had, however, to await further technical developments which produced glass that was hard and could be ground.

The evolution of the spectacle frame has a history of its own. The oldest spectacles, known to us from a painting by di Modena in 1352, consisted of two lenses in rims, joined centrally. The inconvenience of holding such glasses in position for any length of time led to a modification suggesting sugar-tongs. Metal rims gave way to leather ones; such a pair has been found preserved within a book. An early modification – incidentally recommended by Savonarola – was to secure the glasses by a tape tucked under the hat, a method rather reminiscent of the Chinese way of binding the glasses to the headgear. Various forms of lorgnette followed. The original

attempts at ear-rails added greatly to the already heavy weight of spectacles. It was only towards the end of the eighteenth century that passable ear-rails came to be introduced. These were followed by glasses with nose-pieces having a spring, a marked advance on the much earlier nose-riders which were kept in position by the pressure the rims exercised on the nose. Gold, silver, steel, fish-bone, horn, wood and leather have all been used for the making of the spectacle frame.

IX. THE OPHTHALMOSCOPE

WHY the pupil is black was a problem that attracted the attention of Roman writers. It was held that the moisture in the eye was black, and it was also suggested that the blackness resulted from the eye being a sort of deep trough. Yet the Ancients were also acquainted with the fact that some animal eyes are lustrous. Pliny observed that the eyes of nocturnal animals, such as cats, are brilliant in the darkness. The explanation had to wait for many centuries. Mariotte made some approach to it when he noted that the reason a dog's eye is luminous is that its 'choroid' is white, and that hence the image of a light is painted on it clearly, whereas in man and in animals with black 'choroids' no such clear image could be formed. This is a dim realization of the existence of the tapetum. Bidloo in the seventeenth century appreciated that no animal eye radiates light that it has not received, but it was not till 1810 that the simple observation that animal luminosity disappears in complete darkness was established by Prevost. This laid forever such views as those that regarded animal luminosity as a sort of phosphorescence; or that the radiation by night came from light absorbed during the day, or yet again that luminosity was the result of some such internal activity as is seen in the firefly. 'Naked electricity' was yet another explanation that had passed muster. All these views had been invoked to explain the supposition that animals with lustrous eyes could see in the dark.

Further advance towards a clearer understanding was supplied by Rudolphi in 1821. He showed that the luminosity of an animal eye depended largely upon the direction of the ingoing rays. That the problem was a purely physical one he showed by the observation that the eye of a decapitated cat was just as effective for the production of luminosity as that of the living animal. A few years later Esser went further still

by showing that the decapitated cat was really the better as the pupil was widely dilated.

That, at least partially, an optical problem underlay this animal luminosity was indeed also realized more than a century earlier, when Mery in 1703 found that the luminosity of the cat's eye could easily be viewed when the animal was held under water. He appreciated that it was more than mere dilatation of the pupil consequent on suspended animation that was responsible for this phenomenon, and his explanation was that the water filled in unevennesses of the cornea. The correct explanation was advanced by de la Hire six years later, when he argued that the cat's fundus was seen owing to abolition of corneal refraction under water; that consequently the rays emerged divergent, and some of them were thus caught by the observer's eye.

These considerations all seemed to have no practical significance. Even when luminosity in human eyes was observed the problem still remained an academic exercise. Duddell, in 1735, had noted the spontaneous luminosity of the eye of the human albino, as Woolhouse before him had observed it in white rats. Later in the century Fermin had noted luminosity of the eye of an Ethiopian albino (and incidentally held that this patient could thus see at night, because his eyes were like those of night animals). Further interest in spontaneous luminosity of man was aroused by Richter's observation (1790) that in one form of blindness luminosity was present. This led Beer to introduce the term amaurotic cat's-eye for the conditions we know as glioma and pseudo-glioma. Spontaneous luminosity was also noted by Beer in aniridia (1829).

No attempt to explain this spontaneous luminosity in man was made, though a close approach to an explanation had been reached in the case of animals. The observation of Purkinje in 1823 that under certain conditions of illumination

human eyes could be made luminous passed unnoted. It had to be rediscovered independently by Cumming in 1846 and by Brücke in 1847. It was finally realized that the observer had to stand in the path of the emerging rays. Brücke indeed came near to inventing the ophthalmoscope when he looked through a tube placed in the flame of a candle illuminating the eye, and thus caught some of the emergent rays.

A conscious attempt to see the fundus was made by Kussmaul at about the same time (1845). On the basis of de la Hire's explanation of Mery's observation of the fundus of a cat submerged under water, he applied to the eye a plano-concave lens of the same power as the cornea, hoping to see the optic nerve in the living human eye – a procedure that 'should be of great value in the diagnosis of certain eye diseases'. He failed, for he did not realize the necessity for illuminating the eye. Babbage, of calculating-machines fame, is another precursor; but whether he acted just as consciously as Kussmaul, and what exactly he invented, is not definitely known. There is no documentary evidence as to what he made and what he showed to Wharton Jones in 1847, except the latter's account seven years later.

By this time the optical problem underlying luminosity of animal eyes and of the human eye under certain conditions had nearly reached its solution. Indeed, the fact that the eye was not luminous under normal conditions because it forms an optical apparatus which returns entering rays to a focus at the source of illumination had been indicated by the rather crude experiments of Kussmaul. Though he had failed to view the fundus in the living eye by neutralizing the refraction of the cornea, he showed that by further deranging the optical structure of the eye through removal of both the cornea and lens the fundus could be seen, and that it could likewise be seen if some vitreous was extracted and the retina came forward.

The crowning achievement came when Helmholtz announced

the invention of an 'eye-mirror' in December, 1850. His ophthalmoscope consisted not of a mirror but of plates of glass, four plates being used to increase the number of rays reflected into the eye. The illumination was of necessity poor. Modifications followed each other in rapid succession, the silvered mirror with a central hole arriving within a year. Two great improvements were likewise introduced at an early stage. Helmholtz's original ophthalmoscope was mounted with a holder for one lens, and lenses had to be changed constantly for eyes of different refraction. Rekoss, an instrument maker, introduced a revolving disc carrying a series of lenses, whilst Ruete in 1852 introduced the indirect method of ophthalmoscopy. Thereafter an endless series of modifications and improvements followed. The refracting ophthalmoscope was introduced at about 1870, whilst tentative electric ophthalmoscopes were brought out about fifteen years later, one of the earliest being that of Juler in 1886. Search for the ideal source of illumination led to attempts with oil, petrol, gas, daylight and almost every conceivable monochromatic flame.

The introduction of the ophthalmoscope into clinical ophthalmology was facilitated through its brilliant application by von Graefe and his colleagues. Enthusiastically received by them it did not fare so well elsewhere. It was argued that it is dangerous for a diseased eye to be submitted to the strain of all this illumination. Some, more patronizingly, held that it might be quite a useful instrument for such oculists as have poor sight. Dixon of London, in 1853, expressed the fear that its use might lead to amaurosis—'the very condition that he [the practitioner] is hoping to avert.' In France, qualified support was given to the ophthalmoscope, but it was pointed out that some things, such as lens opacities, which can be well seen with a loupe, could not be seen with the ophthalmoscope – as indeed was the case with the earlier models having a concave lens only. It was Anagnostakis who, in 1854, popularized the

instrument in France by a series of excellent observations. In England, pioneer work was done by Spencer Watson, and ardent support came from Bowman, though as late as 1855 the *Lancet* could still speak sceptically of its value. In other countries, Holland excepted, it penetrated even more slowly. Yet by the time the First International Ophthalmological Conference was held in 1857 the ophthalmoscope had come to be sufficiently significant to claim the first discussion.

Within a decade the ophthalmoscope had revolutionized ophthalmology. For one thing, it forced attention to the refractive state of the eye, supplying at the same time objective means of determining it. In no small measure the work of Donders is the result of the introduction of the ophthalmoscope. But even more far-reaching was the demolition of the age-long puzzle of amaurosis. At one stroke endless guesses, speculations, theories and discussions became meaningless. A new conception of glaucoma emerged early, even if at first it was held that in glaucoma no changes were present in the fundus, a view that was replaced by the belief that swelling of the disc was present. But by 1855 von Graefe, who with others had fallen into the earlier error as to swelling, demonstrated excavation and retinal pulsation – and iridectomy as a method of treatment of the hitherto hopeless and badly understood disease followed rapidly. A new chapter – medical ophthalmology – was opened by von Graefe in 1855 and Heymann in 1856 by the description of renal retinitis whilst in 1860 von Graefe presented a boon to neurology by his observation of bilateral papilloedema. Coccius in 1853 described detachment of the retina and indicated retinitis pigmentosa. Thrombosis of the central vein was recognized by Liebreich in 1855, whilst von Graefe recognized embolism of the central artery in 1860.

Amaurosis, the condition which had been defined as one in which the patient saw nothing and the oculist also saw nothing, had ceased to exist.

X. OPHTHALMOLOGY IN THE BRITISH ISLES

ROMAN seals for the preparation of collyria constitute the earliest records of ophthalmology in England. A number of these have been unearthed and one, found in Ireland, presents an interesting historical problem, for the Roman invasion is not supposed to have included that country. These seals are not different from those found elsewhere, so that if any native ophthalmology existed, it does not appear to have influenced the imported practice. Some evidence of ocular treatment in Saxon times is furnished by the extant Saxon Leechdoms; the records speak of a number of herbs, amongst which, as James points out, eyebright is absent – an interesting omission, for eyebright figured largely in later herbals. More significant than this primitive ophthalmology are the learning and investigations that were to be found in the monasteries of Norman England. It is possible that Roger Bacon's contributions represent not an isolated brilliant achievement, but the acme of less far-reaching work that was going on steadily in these secluded seats of learning. James draws attention to Robert Grosseteste, Bacon's teacher, whilst the work of John de Peckham has passed into history – his is the first discussion on the refraction of concave lenses.

The fourteenth century supplies the first native ocular treatise; D'Arcy Power speaks of it as one of the lesser writings of John of Arderne. There are available the original Latin text and an early English translation; a full abstract of it has been published by James in his *Studies in the History of Ophthalmology in England*. It is largely a formulary and its most interesting passage is an autobiographical reference. It is only towards the end of the sixteenth century that an ophthalmic literature worthy of the name makes its appearance in England.

Short chapters on the eye occur in Philip Barrough's *Method of Physick*, the first edition of which appeared in 1583. They are of no particular significance. Of not much greater significance is Walter Bayley's *Briefe Treatise touching the Preservation of the Eyesight, consisting partly in Good Order of Diet and partly in Use of Medicines*, first published in 1586. Bayley was physician to Queen Elizabeth, but his knowledge of ophthalmology extended to little beyond doubting the efficacy of urine for bathing the eye and recommending ale as strengthening the sight. Sometime between 1586 and 1589 appeared a translation of Jacques Guillemeau's *Maladies de l'Œil*, a useful summary of the existing knowledge, mainly on Greek and Arabian sources, by a pupil of Ambroise Paré. The century closed with another translation, Andreas Laurentius' *Discourse of the Preservation of the Eyesight*. In the second decade of the seventeenth century appeared another tract, *Two Treatises concerning the Preservation of Eiesight*, the first one being a reprint of Bayley's essay, whilst the second – an anonymous 'scissors and paste' production drawn from the writings of Benevenutus of Jerusalem, Riolanus and Fernelius – contains nothing new. British ophthalmology had yet to be born.

Its beginnings were created by Richard Banister in 1622. In that year he reissued the translation of Guillemeau's book, for this 'worke . . . being long since out of print, it is not now to be bought for money'. He sent it 'abroade again, that those which delight to labour in this Art, may runne the readier way to the better successe'. He added a *Breviary*, 'something of mine owne, that through my experience they may finde at first, what I was learning long'. That something of his own is not always useful, but contains much that bears the stamp of the experienced oculist. Much the most significant passage is the one in which hardness of the eye is described as a diagnostic and prognostic feature in the treatment of *gutta*

serena – an observation that fell on stony soil and had to be rediscovered in the nineteenth century. Banister's *Breviary* is also of inestimable value as a document on the social standing of oculists in that age. He relates in a delightfully naïve way how he came to devote himself to the study of diseases of the eye; and in criticizing ignorant practitioners he has left a sidelight on the practice of ophthalmology in his days: –

'... My special breeding has beene in the general skill of Chirurgerie. ... I left the greatest masse of that unmeasurable mysterie, as a heape too heavy for my undergoing; to take up onely some particular pieces, wherein I might the better proceed to some perfection: choosing rather to walk in a right line, whose very beginning points to a certaine end; then to run in a ring, whose mazefull compasse foretells much paine with little progresse, or a long journey without an Inne. ... I thought the Art would be no loser by me, if I did let goe many parts of her, to hold the rest more sure and certaine. And finding some defects in mine owne eyes, I chose their cure for my care, that so I might benefit my selfe first, and otheres after by mine owne experience: unto this also I adioyned the helpe of Hearing by the instrument, the cure of the Hare-lip, and the wry Necke. When in the threshold of my practice, I could couch the Cataract, and so began to gaine some name of an Oculist, I laboured to advance my skill by the advice of the most skilfull in those times: ... Byt in observing them, I noted much practice, but little Theorie; therefore not contenting my selfe to have but one string to my bow, lest time of night might overtake me wanting oyle in my lampe; and labouring to bee as cunning in knowledge of the reason, as perfect in practice upon the occasion; I addressed my selfe to the study of divers best approved Authors, ... And hereby wee see the boundlesse boldnesse of many women, who for lacke of learning, cannot be acquainted with the Teoricke part, and yet dare venture on the Practicke. I beleeve, scarce three of thirteen hundred, can define or describe the names and natures of the hundred and thirteene diseases of the eye; to shew whether they be in the Humors, Membranes, Muscles, Optick Spirits, etc., yet having snatched up some one or two medicines onely, they thinke themselves armed against all diseases. ... Let these women therefore either applie themselves to learne the grounds of their practice, or leave their practice to them that are better grounded; that so they may cease by their ignorance to make them blinde, that by our Arte might be made to see. Many have come from these to me, lighted more by sorrow than by sight, with their eyes full of teares, but empty of opticke humors. And yet these firebrands that choke and smoke folks eyes out, can take hennes, chickens, and such reasonable rewards for their unreasonable wrongs'.

Further on he relates: '*Of proud quacksalving Mountebankes, that would undertake all Cures, and performe few*'.

'Such are they, that promise to make blind people see, deafe people heare, and to cure the Stone and Rupture by cutting. In the methodicall practice and cure of blind people, by couching of Cataracts, our English Oculists have alwayes had an expeciall care, according to Arts, to couch them within doores, out of the open aire, to prevent further danger. Yet some of these Mountebanks take their Patients into open markets, and therefore vaineglories sake, make them see, hurting the Patient, only to make the people wonder at their rare skill. Some others make Scaffolds, on purpose to execute their skill upon, as the French-men, and Irish-man did in the Strand, making a trumpet to be blowne, before they went about their work. But these were not long suffered to use these lewd courses, before they were called before the company of the Chirurgions: being sharply reprooved, soone left the City, and their abusive practice.... Beside this lewd practice, some of the afore mentioned, will cut for the Stone and Rupture, when by other meanes they might performe the Cure and wicked practice.... The skins of which, these Empericks take away, they stuffe with wooll, or flax, to make them shew the greater, and these they hang upon a wall, or post, in the open markets, to make their gelding skill more knowne'.

Banister was an itinerant oculist. He relates of his cures in Norwich, London, Lincoln and elsewhere, cures testified by the magistrates. His apologia for his itinerant activities and advertisements is delightful: –

'... It may be, some will object, as they have done, I need not have travelled so farre from home to do these Cures: for they would have come to me. I answere, Three causes made me to do this: first, when I was abroad, and made my selfe knowne in a strange place, I did see more defected Eyes in one moneth, then I should have seen in halfe a yeare at my owne house, whereby my knowledge and skill was increased so much the more, for the true judgement in defective Eyes. Secondly, if I had not made my Practice publikely knowne abroad, I should have had no resort to me at home, so that my small talent might have been hid in oblivion. Thirdly, Many poore people that wanted help, as well as rich, were not able to travell so far to me for helpe; both in respect of the weakness of their bodies, and disability of their estates, which I willingly helped as wel as others'.

To Banister must also be ascribed an anonymous manuscript discovered by James in the Sloane Collection at the British Museum. A 'Briefe discourse of ye Chefeste Oculistes' is

valuable for the light it throws on the ophthalmic practice of the day. It supplements the information contained in his *Breviary*.

There was Luke of Erithe,

> 'a man that lived in greate fame and credite had the greatest practise and sumes of money for he hathe had from XX to LX L for Cataracke couchinge. . . . He neuer set up bils that I heard of but those that desyred his helpe & dwelled far from him he would appoynte a tyme to come to them and would wyshe ym to gyve notis of his comminge to alle they knewe stoode in need of his helpe'.

No less interesting was Mr. Surphlete, a man,

> 'of axeolente Dyet and crusty fasion of bodye. He lived till he was fouere score yeares of age lived moste in Norfolke & dyed at Linn and in good estate. He lay 2 or 3 yeares at a barber's house at Linn to whom he taught som skille, who nowe professethe it wth weak Understandinge and gyven to drinke I cannot com'end this Mr. Surphlete for any extra-ordinarye skille though of longe experience'.

But most interesting of all was Henry Blackbourne,

> 'who travelled contynuouslye from one market towne to another, who could couche ye Cataracke welle, cure yt, Laye a scar Lipe, set a crockt necke strayght & helpe deafness. Though he could doe good in these cures yet he was so wickedlye gyven that he would cousen & deceave men of great som of moneys by taken incurable diseases in hand. He was lusty amorously gyven to seueral women so that his coseninge made him fearfully to flee from place to place and often changed his name and habits in divers places & was often imprisoned for women. His skille was excelente, but his vices . . . *longus*, his practeste was this, yf he made a blinde man see; after he had couched ye Cataracke . . . yf he herde they did welle he woulde see ym agayne, yf not he would neuer come at ym. If cum payne or accedentyles fell out they receaved no comforte from him. . . . Though before I com'ended him for a good oculist it was for his manuel operation & not his method or medicines. He dyed in Kent after he had thoroughly travelled alle partes of the lande, he left no memories of his gaynes or gettinges his wicked lyfe was suche that I thinke he had not one friend that he trusted, but alwayes that he got he caryed about with him. He was often deceaued of great sums of money yet neuer robbed. He dyed but in meane estate had one sonne and left him nothing'.

From the number of oculists Banister names, it is clear that a fairly extensive specialist practice in eye disease was in

existence in Elizabethan England. English ophthalmology, from its inception, had both medical and surgical inspiration. A limited licence to practise the treatment of eye disease is known to have been granted to John Luke by the College of Physicians in 1561, whilst Henry Blackbourne was licensed by the Archbishop of Canterbury in 1612 to practise eye surgery. Banister himself was a 'practitioner in physicke' and was approved in surgery generally by the Company of Surgeons. Professional standards do not, however, appear to have been high, and apart from the solitary exception of Banister's observation on the hardness of the eye, there is not much to excite admiration when the curtain first rises on English ophthalmology. And the rest of the seventeenth century offers little relief. Robert Turner in 1654 and again in 1665 brought out 'The Compleat Bone Setter', in which a section is devoted to the *Perfect Oculist*, this itself being nothing more than an unacknowledged adaptation of the anonymous tract published in 1616. But the century did not close altogether in this bleak fashion. Orthodox practitioners were turning to the study of the eye. Daubigney Turberville of Salisbury was a qualified practitioner of great repute; though not on good terms with the Court physicians he was called in to treat the future Queen Anne. The *Philosophical Transactions* contain two letters of his, in one of which an account is given of the use of a magnet to withdraw a piece of steel embedded in the 'iris' [limbus]. William Briggs' Latin treatise on the anatomy of the eye, containing the first account of the optic disc, belongs to this period. Briggs was more than an anatomist; his *Theory of Vision* is of interest as showing the searching that was going on for new explanations. Another qualified practitioner of that period, though hardly worthy of consideration together with Turberville and Briggs, is William Coward. His Latin *Ophthalmiatria*, published in 1706, is of little significance.

Coward's book was one of three that appeared in the first decade of the eighteenth century. The two others were even more insignificant than his. *A Brief Treatise of the Eyes* by William Crosse is a rather long advertisement of the author's secret remedies, whilst Sir William Read's *Treatise for the Eyes* is an unacknowledged reprint of Banister's *Breviary* and the translation from Guillemeau, together with a rodomontade on Read's manual dexterity and styptic water. Read's *Short but Exact Account of all the Diseases Incident to the Eyes* is but the same production with a different title page; it is not even a reprint. A rather more significant publication was Peter Kennedy's *Ophthalmographia*, published in 1713; if unoriginal, it is at any rate honest.

The conflict between orthodoxy and quackery was to last for the rest of the century, largely because of the indifference of the profession to ophthalmic matters. Benedict Duddell had to complain in 1729 that surgeons undertook treatment of eye conditions without the necessary knowledge: 'to the question how a certain surgeon did to know the different natures of the distempers of the eye: His answer was that he undertook all. If his operation succeeded, so much the better; if not, the patients could but be blind, or in danger of being so, as they were before.' In such an atmosphere charlatanism could not but prosper, especially as the charlatan was often well grounded in the subject; Woolhouse and the Chevalier Taylor were certainly the equals in knowledge to most of the more orthodox oculists. Though Cheselden, who introduced the operation for artificial pupil, and Duddell, who wrote an excellent monograph on the cornea, flourished in the first half of the century, significant names of surgeons who were interested in eye diseases begin to appear only in the second half. Amongst the earliest was Sharp of Guy's Hospital, a pupil of Cheselden; he contributed the single incision by puncture and counter-puncture to the operation for extraction of cataract, whilst

towards the end of the century Ware contributed to the recognition of the venereal origin of ophthalmia. Yet even so, Benjamin Bell, writing in 1785, had to complain that the difficulty in deciding whether couching or extraction is the better operation is due to the fact that operations are left to itinerant practitioners.

The century closed as it began – by plagiarism. William Rowley's *Treatise of One Hundred and Eighteen Principal Diseases of the Eyes* is an unacknowledged and faulty translation of Plenck's *Doctrina de Morbis Oculorum.* Quackery, charlatanism and plagiarism is the unenviable record of the eighteenth century in England, a century during which modern clinical ophthalmology was being built up by orthodox practitioners in France. But the growing number of surgeons who studied eye disease, and the advent of Porterfield in Edinburgh and Thomas Young in London, carried the promise which matured early in the succeeding century.

That maturation centred largely around the creation of special eye hospitals. As early as 1771 William Rowley had founded the St. John's Hospital for Diseases of the Eyes, Legs and Breasts. It did not survive for more than two or three years: In 1804, on the initiative of Jonathan Wathen, Oculist to George III, the Royal Infirmary for Diseases of the Eye was established in Cork Street, London. This existed till 1871 and throughout the whole of its career it was largely a personal venture controlled by Henry Alexander and his son, Charles. Though established with less support, the London Dispensary for the Cure of Diseases of the Eye and Ear, which came a year later, developed into a significant public institution, which rapidly became exclusively an eye hospital, and subsequently became known as the Moorfields Eye Hospital. Of the existing eye hospitals in London, the Royal Westminster Ophthalmic was established in 1816, the Central London in 1843, the Western Ophthalmic in 1856,

and the Royal Eye Hospital a year later. These five eye hospitals were, however, the survivors of a much larger group which came into existence. It is uncertain how many arose before 1840, but between 1840 and 1860 at least eight came into being. The most significant of these was the North London Ophthalmic Institution. This was served by a brilliant staff, but disappeared after about twenty years. After 1860 only two further tentative and short-lived attempts are known.

In Dublin the National Eye Hospital was founded in 1814 and St. Mark's Ophthalmic Hospital in 1841. These amalgamated in 1897 to form the present Royal Victoria Eye & Ear Hospital. Four evanescent institutions developed between 1814 and 1841 and one more came in 1872. In the provinces of England and in Wales the movements for the creation of eye hospitals began with the founding of the West of England Eye Infirmary at Exeter in 1808, and it is known that fifty-two eye, or eye and ear hospitals, were established between 1808 and 1889. Of these fifty-two, twenty-three have survived. Many of those that failed to survive were small institutions situated in geographically unpromising or declining areas, but even significant eye hospitals in large provincial centres disappeared when the local general hospitals began to open ophthalmic departments. The movement for special eye hospitals which came to an end in London by 1860, and some thirty years later in the provinces, had, however, established ophthalmology as a recognized specialty. The immense development in facilities that these eye hospitals and eye departments had created led to the emergence of a substantial body of ophthalmic surgeons, so that, when the Ophthalmological Society of the United Kingdom was established in 1880, its foundation registered the secure position that ophthalmology had already achieved. By then the tradition that ophthalmology was a branch of general

surgery which could be practised adequately by the general surgeon, had almost come to an end, whilst quackery as a force had disappeared without a struggle, once the need for orthodox practitioners with knowledge of eye disease had been satisfied.

The activities of the new generation of ophthalmic surgeons led to the publication of a number of textbooks, and in the third decade three books – the first adequate books on ophthalmology in English – made an almost simultaneous appearance: William Mackenzie's in 1830, Sir William Lawrence's in 1833 and Richard Middlemore's in 1835. These, like Wardrop's *Essays on the Morbid Anatomy of the Human Eye*, were no longer acknowledged or unacknowledged translations of continental books, but valuable and valued contributions to ophthalmic literature. Henceforth on the exchange of world ophthalmology, British ophthalmology, to quote one of its makers, had come to barter not to borrow.

The first ophthalmic periodical was John Richard Farre's *Journal of Morbid Anatomy, Ophthalmic Medicine and Pharmacological Analysis, with Medico-Botanical Transactions communicated by the Medico-Botanical Society*. Only one issue appeared, and in a way the journal may be considered as the precursor of the *Royal London Ophthalmic Hospital Reports*, first published in 1857. In the meantime Richard Middlemore in 1837 had mooted the idea of a *Journal of Ophthalmology*, but nothing beyond a prospectus appeared. The first exclusively ophthalmic journal, planned on a wider scale than the *Ophthalmic Hospital Reports*, came in 1864 with the publication of the *Ophthalmic Review*, edited by John Zachariah Laurence and Thomas Windsor. The journal, a quarterly, lasted barely four years; it is possible that Laurence's ill-health and death at the age of 41 were responsible for its decline – a matter for regret, for the *Review* deserved a better fate. One undesirable consequence of the appearance of the *Review* was the publica-

tion by Jabez Hogg of a *Journal of British Ophthalmology* in 1865, frankly as a counter-move to Laurence; only one issue appeared. The [second] *Ophthalmic Review* began to appear in 1881, and British ophthalmology had yet to see the rise of the *Ophthalmoscope* (1903) before it achieved its present central organ in *The British Journal of Ophthalmology* (1917).

The names of many of the makers of nineteenth century ophthalmology in the British Isles – Mackenzie, Jacob, Bowman, Critchett, Laurence, Hutchinson, Tay, Argyll Robertson, Priestley Smith, Nettleship, Doyne, Marcus Gunn, McHardy, to mention only a few – have become household words in ophthalmic practice. To their successors their work is a cherished tradition and a living inspiration.

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